PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : C02F 1/78

A2

(11) International Publication Number: WO 00/27760

(43) International Publication Date: 18 May 2000 (18.05.00)

(21) International Application Number: PCT/CA99/01050

(22) International Filing Date: 8 November 1999 (08.11.99)

(30) Priority Data:

| | | |
|---|---|---|
| 2,253,689 | 9 November 1998 (09.11.98) | CA |
| 2,253,101 | 9 November 1998 (09.11.98) | CA |
| 2,253,079 | 9 November 1998 (09.11.98) | CA |
| 09/240,619 | 1 February 1999 (01.02.99) | US |
| 09/240,617 | 1 February 1999 (01.02.99) | US |
| 09/240,615 | 1 February 1999 (01.02.99) | US |

(63) Related by Continuation (CON) or Continuation-in-Part (CIP) to Earlier Applications

| | |
|---|---|
| US | 09/240,617 (CIP) |
| Filed on | 1 February 1999 (01.02.99) |
| US | 09/240,615 (CIP) |
| Filed on | 1 February 1999 (01.02.99) |
| US | 09/240,619 (CIP) |
| Filed on | 1 February 1999 (01.02.99) |

(71) Applicant *(for all designated States except US)*: FANTOM TECHNOLOGIES INC. [CA/CA]; 1110 Hansler Road, Welland, Ontario L3B 5S1 (CA).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: CONRAD, Wayne, Ernest [CA/CA]; 27 King Street, Hampton, Ontario L0B 1J0 (CA). CONRAD, Helmut, Gerhard [CA/CA]; 27 King Street, Hampton, Ontario L0B 1J0 (CA). PHILLIPS, Richard, Stanley [CA/CA]; 24 Devondale Street, Courtice, Ontario L1E 1S1 (CA).

(74) Agent: BERESKIN & PARR; 40th floor, 40 King Street West, Toronto, Ontario M5H 3Y2 (CA).

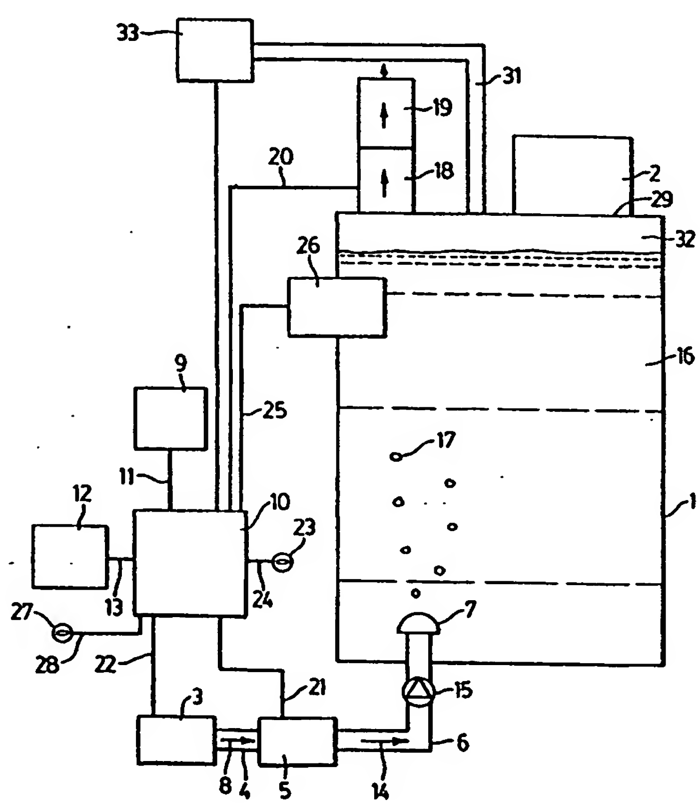
(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

**Published**
*Without international search report and to be republished upon receipt of that report.*

(54) Title: PRESSURE SWING CONTACTOR FOR THE TREATMENT OF A LIQUID WITH A GAS

(57) Abstract

A residential method for treating water with an ozidizing gas operates under elevated pressure. The elevated pressure is obtained by means of a pressurized oxidizing gas source (e.g. an air pump) or a prandtl layer turbine. The elevated pressure of the treated water is optionally used to dispense the treated water. The prandtl layer turbine may be used to obtain particularly fine bubbles of a gas (e.g. bubbles from about $1\mu$ to about $20\mu$ in diameter) in a liquid.



*FOR THE PURPOSES OF INFORMATION ONLY*

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| AL | Albania | ES | Spain | LS | Lesotho | SI | Slovenia |
| AM | Armenia | FI | Finland | LT | Lithuania | SK | Slovakia |
| AT | Austria | FR | France | LU | Luxembourg | SN | Senegal |
| AU | Australia | GA | Gabon | LV | Latvia | SZ | Swaziland |
| AZ | Azerbaijan | GB | United Kingdom | MC | Monaco | TD | Chad |
| BA | Bosnia and Herzegovina | GE | Georgia | MD | Republic of Moldova | TG | Togo |
| BB | Barbados | GH | Ghana | MG | Madagascar | TJ | Tajikistan |
| BE | Belgium | GN | Guinea | MK | The former Yugoslav Republic of Macedonia | TM | Turkmenistan |
| BF | Burkina Faso | GR | Greece | | | TR | Turkey |
| BG | Bulgaria | HU | Hungary | ML | Mali | TT | Trinidad and Tobago |
| BJ | Benin | IE | Ireland | MN | Mongolia | UA | Ukraine |
| BR | Brazil | IL | Israel | MR | Mauritania | UG | Uganda |
| BY | Belarus | IS | Iceland | MW | Malawi | US | United States of America |
| CA | Canada | IT | Italy | MX | Mexico | UZ | Uzbekistan |
| CF | Central African Republic | JP | Japan | NE | Niger | VN | Viet Nam |
| CG | Congo | KE | Kenya | NL | Netherlands | YU | Yugoslavia |
| CH | Switzerland | KG | Kyrgyzstan | NO | Norway | ZW | Zimbabwe |
| CI | Côte d'Ivoire | KP | Democratic People's Republic of Korea | NZ | New Zealand | | |
| CM | Cameroon | | | PL | Poland | | |
| CN | China | KR | Republic of Korea | PT | Portugal | | |
| CU | Cuba | KZ | Kazakstan | RO | Romania | | |
| CZ | Czech Republic | LC | Saint Lucia | RU | Russian Federation | | |
| DE | Germany | LI | Liechtenstein | SD | Sudan | | |
| DK | Denmark | LK | Sri Lanka | SE | Sweden | | |
| EE | Estonia | LR | Liberia | SG | Singapore | | |

# Title: PRESSURE SWING CONTACTOR FOR THE TREATMENT OF A LIQUID WITH A GAS

## FIELD OF THE INVENTION

This invention relates of a domestic apparatus for treating a liquid such as water with a gas such as ozone. The apparatus may be used in the production of water suitable for human consumption from water contaminated by one or more of microorganisms, chemicals, heavy metals and minerals. The gas may be present either by itself or in combination with one or more other gasses and/or one or more other liquids associated therewith. Further, the liquid with which the gas is reacted may be present by itself or may also have one or more liquids and/or one or more other gases associated therewith.

## BACKGROUND OF THE INVENTION

The production of water suitable for human consumption from water contaminated by one or more of microorganisms, chemicals, heavy metals and minerals is a requirement throughout the world. Many different proposals have been made for the purification of contaminated water.

A popular system in widespread use for the purification of contaminated water is a filtration based system. Such systems use a filter made from a combination of a porous media filter, activated carbon, and an ion exchange resin through which the contaminated water is passed. The filtered water is typically fed into a clean water reservoir. This type of system will reduce the levels of chlorine, lead, and pesticides. However, there are several disadvantages associated with this device.

The first disadvantage of this water purification system is that the structure of the filter provides a breeding ground for microorganisms thereby multiplying the dangers of microorganisms which may be present in very low numbers.

Another disadvantage of such a water purification system is that the filter life is not measured and it is possible for the user to employ the filter beyond its useful life. A further disadvantage of such a water purification system is that oils and fuels often present in water drawn from lakes and rivers are not readily removed. Further, these oils and fuels tend to coat the filters and damage their operational life and effectiveness. Some filtration based products now incorporate a means of measuring the water volume passing though the filter and an indicator as to when to change the filter. Other filters incorporate an iodine product to minimize the risk of microbiological hazards, however, these materials often impart undesirable tastes and many are potential carcinogens.

Another popular system in use for the purification of contaminated water is a system which employs ultraviolet light for disinfection in series with a porous media and carbon filter. This type of system will reduce the levels of chlorine, lead, and pesticides and has some disinfection capability. One disadvantage with this system is that the ultraviolet light's disinfection efficacy is greatly diminished by turbidity or color in the water which can cause the filter to become contaminated by microorganisms which can readily live and breed therein thereby multiplying the danger from any microorganisms which may be present. Thus, the filter of this system also suffers from the disadvantages associated with filters of filtration based systems.

## BRIEF SUMMARY OF THE INVENTION

In accordance with the instant invention, there is provided a method for treating a liquid with a gas in a sealed vessel comprising the steps of:

(a) introducing the gas into the sealed vessel;

(b) promoting the dissolution of the gas into the liquid by increasing the pressure in the vessel; and,

(c) reducing the pressure when the pressure in the vessel reaches a predetermined level.

The method may also include the additional steps, after step (c), of:

(d) repeating steps (a) through (c) until the liquid is treated to a predetermined level; and

(e) signalling a user that the treatment is complete.

In accordance with another embodiment of the instant invention, there is provided a method for treating a liquid in a sealed vessel with a gas comprising the steps of:

(a) introducing the gas into the sealed vessel;

(b) promoting the dissolution of the gas into the liquid by increasing the pressure in the vessel; and,

(c) monitoring the treatment of the liquid and reducing the pressure when the treatment of the liquid in the vessel reaches a predetermined level.

In one embodiment, the method also comprises the step of signalling a user that the treatment is complete.

In another embodiment, the pressure in the sealed vessel is increased by supplying pressurized gas to the vessel.

In another embodiment, the gas comprises ozone and the method additionally comprises the step of, prior to step (a), generating ozone in an ozone generator. The method may further comprise the step of, prior to generating ozone, concentrating a source of oxygen to produce an oxygen enriched stream which is supplied to the ozone generator.

In another embodiment, step (a) comprises introducing the gas into the sealed vessel by passing the gas through a disperser positioned to finely disperse the gas in the liquid.

In another embodiment, the liquid comprises water to be treated for human consumption and the gas comprises ozone and the method comprises a method for treating water.

In another embodiment, the method further comprises the step of monitoring the treatment of the liquid and signalling the user that the liquid has not been fully treated.

In accordance with another embodiment of the instant invention, there is provided an apparatus for treating a liquid with a gas comprising:

(a) a vessel having a gas inlet port for introducing a pressurized gas into the vessel, a liquid inlet port for introducing a liquid into the vessel and, a gas outlet port for removing gas from the vessel;

(b) a source of pressurized gas for treating the liquid in communication with the gas inlet port;

(c) a disperser for introducing the gas into the liquid in the vessel; and

(d) a valve for reducing pressure in the vessel after the gas in the vessel reaches a predetermined pressure.

In one embodiment, the apparatus further comprises a valve for releasing pressure from the vessel when the treatment reaches a predetermined level

In accordance with another embodiment of the instant invention, there is provided an apparatus for treating a liquid with a gas comprising:

(a) a vessel having a gas inlet port for introducing a pressurized gas into the vessel, a liquid inlet port for introducing a liquid into the vessel and a gas outlet port for removing gas from the vessel;

(b) a source of pressurized gas in communication with the gas inlet port;

(c) a disperser for introducing the gas into liquid in the vessel; and,

(d) a sensor for monitoring the treatment of the liquid in the vessel and signalling a user when the treatment reaches a predetermined level.

In one embodiment, the apparatus further comprises a pressure activated valve for releasing pressure from the vessel when the treatment reaches a predetermined level.

In another embodiment, the apparatus further comprises a check valve located between the gas inlet port and the source of pressurized gas, to prevent fluid from flowing upstream to the source of pressurized gas.

In another embodiment, the gas comprises ozone and the liquid comprises water.

In another embodiment, the source of pressurized gas comprises an ozone generator. The apparatus may further comprise an oxygen concentrator for supplying an oxygen enriched stream to the ozone generator.

In another embodiment, the vessel is removable from the apparatus.

In another embodiment, the apparatus further comprises a signal to signal the user when the treatment reaches a predetermined level.

In another embodiment, the apparatus further comprises a signal to signal the user when the treatment is successfully completed.

## BRIEF DESCRIPTION OF THE DRAWINGS

A further, detailed description of the invention, briefly described above, will follow by reference to the following drawings of a preferred embodiment of the invention in which:

Figure 1 shows a schematic representation of the apparatus according to the instant invention;

Figure 2 shows a schematic representation of an alternate apparatus according to the instant invention;

Figure 3 is a schematic representation of a mixing vessel that may be used in the embodiments of Figures 1 and 2.

Figure 4 shows a schematic representation of an alternate apparatus to that of Figure 3;

Figure 5 shows a schematic representation of a further alternate apparatus to that of Figure 3; and,

Figure 6 shows a schematic representation of an alternate apparatus according to the instant invention.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In one preferred embodiment, the apparatus is for use in a domestic (i.e. residential) environment, eg. a house or a cottage, and the water to be treated may be from a municipal water supply which is fed to a house through supply pipes. It may also be water which is obtained from a well maintained by the individual or any other source that the individual has for their house or cottage. Thus, the apparatus may be used in various domestic applications, such as a counter top water purifier, a point of entry or point of use (under counter) water purifier. Further, it may be used as a portable water purifier.

The liquid is treated in a container 1. Container 1 may be of any particular design that will allow the pressure exerted on the liquid being treated therein to be increased. The liquid and the gas may be introduced into the container by any method known in the art. For example, container 1 may have an inlet port for the liquid to be treated and a separate inlet port for the gas to treat the liquid. Alternately, the liquid and the gas may be introduced

through the same inlet port. While some of the gas may be introduced into container 1 when at least some of the liquid is in container 1, it is preferred that all of the gas is introduced into container 1 once a full charge of liquid to be treated has been introduced into container 1.

The apparatus is designed to permit pressure to build up in container 1 during use. The pressure in container 1 may be increased by the introduction of the fluids into container 1. Preferably, the pressure is increased at least in part by the introduction of gas into container 1 when container 1 has already been provided with at least part of charge of the liquid to be treated. More preferably, the pressure is increased by the introduction of gas into container 1 when container 1 has already been provided with a full charge of the liquid to be treated.

Figure 1 schematically illustrates a system for efficiently dissolving ozone in water and subsequently causing microbubble formation to disinfect the water and oxidize pollutants present. While the system will be described herein in relation to the use of ozone to treat water, it will be appreciated that it may also readily be modified for use with any system wherein at least one gas is used to treat at least one liquid.

Water 16 is introduced into container 1 through liquid inlet port 29. Liquid inlet port 29 may be supplied by a hose. Alternately, liquid inlet port 29 may comprise an opening through which water may be poured such as from a jug, faucet or the like. Liquid inlet port 29 is sealable so as to allow pressure to build up in container 1 during the treatment of water 16. As shown in Figure 1, liquid inlet port 29 may receive a resealable cap 2. The cap 2 may be removably affixed to container 1 by any means, such as by a screw thread or a bayonet mount. When the cap is closed, the container is sealed.

It will be appreciated that container 1 may allow some fluid to escape therefrom during the treatment of water 16 (eg. some of the treatment gas may exit container 1 during the treatment). In such an embodiment, liquid inlet port 29 may only be partially sealed. For example, as shown in Figure 2, a bleed stream 31 of off gas may be fed to sensor 33 to monitor the progress of the treatment cycle. Preferably all of the fluid is maintained in container 1 until the treatment cycle is completed and accordingly liquid inlet port 29 is preferably fully sealable.

The control circuit of this device derives power from any power source, for example, a battery 12 by means of wire 13. The power source could also be, for example, an electrical outlet. A user may then activate the unit by pushing start button 9 which sends a signal to the controller 10 through the wire 11. The unit may be actuated by any other means known in the art. For example, the unit may be actuated when cap 2 is sealed or, if the water is supplied via a hose, when a sensor (eg. a float switch) detects a full charge in container 1.

The unit is provided with a source of ozone. This may be a canister of compressed ozone gas which is provided as part of the unit or fed to container 1 via a hose (not shown). Preferably, the device includes an ozone generator and the ozone generator is supplied with a source of oxygen. This source of oxygen may be the ambient air. Preferably, oxygen enriched air is used. Accordingly, the unit may be connected to a source of oxygen enriched air for example the unit may be provided with a canister of compressed gas containing elevated levels of oxygen or pure oxygen, or it may be connected via a hose to such a source or, preferably, the unit may include an oxygen concentrator, such as those which utilize pressure swing adsorption and are known in the art. Pressurized air

may be provided to an oxygen concentrator such as by a motor driven fan, or any other manner known in the art (not shown).

The apparatus includes means for increasing the pressure in the treatment vessel. In the embodiment of Figure 1, this means comprises air pump 30. Air stream 34 (eg. ambient air) is fed to air pump 30. In the embodiment of Figure 3, this means comprises prandtl layer turbine 56. Any pressurization means known in the art may be used (eg. a water pump through which water 16 and ozone oxygen mixture 14 are fed to container 1).

When the unit is actuated (eg. when start button 9 is pushed), ozone is fed to container 1. If the device includes an ozone generator as shown in Figure 1, then the control circuit provides power to the oxygen gas source 3 (eg. an oxygen concentrator) and to the ozone generator 5 through wires 21 and 22, respectively.

The oxygen gas source 3 provides gas containing oxygen 8 which is preferably at an elevated pressure (eg. 30 psi). If the gas 8 is at an insufficient pressure, then a pump may be provided at any point prior to the entry of the gas into container 1 to boost the pressure of the gas as it enters container 1. Gas 8 then flows from the oxygen rich gas source 3 through tube 4 and into the ozone generator 5 where at least a portion of the oxygen present is converted to ozone. This ozone oxygen mixture 14 generated by the ozone generator then flows through the pipe 6, through the one way check valve 15 and into the water 16 through, eg., sparger 7 which serves to disperse the gas in the water 16 in the form of into fine bubbles 17 (eg. having a diameter from about 50μ to about 100μ). Other means may be used to introduce mixture 14 into container 1 so as to form a stream of bubbles including venturis and the use of a prandtl layer turbine.

A prandtl layer turbine may be used to mix the ozone with some of the water which may then be fed to container 1.

Various embodiments of prandtl layer turbines have been developed over the years. Prandtl layer turbines comprise a plurality of rotatably mounted members (generally in the form of flat discs which are typically relatively thin) which are rotatably mounted in a housing. These devices are described in the United States Patent No. 1,061,206 (Tesla). The method and apparatus of the instant invention is applicable to all designs of a prandtl layer turbine.

Referring to Figure 3, water 16 (from feed tube 35) and ozone containing gas 50 are introduced into a housing 52, for example, by being drawn through a venturi 54 by means of a prandtl layer turbine 56. The prandtl layer turbine 56 consists of a series of plates (preferably discs) 58 which are non-rotatably mounted to a shaft 60 which is itself rotatably mounted in housing 52 such as by being connected to a motor 62 which provides the motive force to rotate the plates 58. The rotation of the plates 58 causes the fluid to be drawn through the venturi 54 which in turn causes gas 50 to be drawn from the hose 14 into the venturi 54. It will further be appreciated that the gases and the liquids may be separately introduced into prandtl layer turbine 56.

Gas 50 and water 16 are preferably mixed prior to their introduction into prandtl layer turbine 56. More preferably, the gas 50 is preferably mixed with water 16 in such a manner as to form small gas bubbles 64 in the fluid flow stream. The bubbles may vary in size from about 50 to about 250 microns in diameter, more preferably from about 50 to about 100 and, most preferably, 50 to about 75. It will further be appreciated that various other devices besides venturi 54 may be used to create bubbles 64, such as a sparger. By creating a plurality of small gas bubbles 64 which are introduced into prandtl layer turbine 56, the surface area of gas 50 in water 16 which is introduced into prandtl layer turbine 56 is

increased thereby increasing the dissolution which may be achieved of gas 50 into water 16 in prandtl layer turbine 56.

The gas laden fluid stream 66 is drawn through venturi 54 and into the spaced apart plates 58 such as via openings 68 in plates 58. As the fluid is forced outwards on a radial serpentine path along the rotating plates 58 the pressure of the fluid increases thereby increasing the dissolution of the gas 50 into water 16. This increase in the pressure of the fluid is possible because, unlike conventional vane or centrifugal pumps, plates 58 in prandtl layer turbine 56 will not be cavitated by the presence of the gas. The prandtl layer turbine may create a force of, for example, up to 100 psig and, more preferably up to 250 psig. The fluid with the gas dissolved therein may be sent to other apparatus for further processing.

Alternately, the pressurized liquid mixture 70 may then be subjected to a reduced pressure. For example, the pressurized gas and liquid mixture 70 may be passed into an expansion zone 72 (which may be container 1) wherein the pressure to which the gas and liquid mixture 70 is subjected is reduced and preferably rapidly reduced. Container 1 may already be at a reduced pressure so that the pressure reduction occurs upon the mixture entering container 1. Alternately, mixture 70 may be fed to container 1 at an elevated pressure and the pressure reduced once mixture 70 has been fed to container 1. For example, mixture 70 may be fed to container 1 and the pressure is partially reduced to allow microbubbles to form. A sensor may be used to monitor the treatment of the water and when the water is treated to a desired level of purity, the pressure in container 1 may be further reduced. Alternately, the elevated pressure may be used to dispense the treated water.

The liquid/gas mixture in the expansion zone may be at a pressure of, for example, 30-60 psig. This depressurization may

occur in under 2 seconds, preferably under 1 second and, most preferably, is effectively instantaneous upon the liquid/gas mixture entering expansion zone 72. This depressurization allows the dissolved gas to come out of solution to form a suspension of ultra-fine bubbles 17. The bubbles may vary in size from about 1μ to about 20μ in diameter, more preferably from about 1 micron to about 5 μ and, most preferably, from 1μ to 3μ. Due to the relatively fine nature of the bubbles, a large increase in the surface area of the gas is achieved. If the pressure reduction is conducted so as to achieve bubbles which are a few microns in diameter, then the number of bubbles which are achieved may be sufficiently high such that mixture 70 becomes translucent and, preferably, opaque. By varying the rate of pressure reduction and the amount of the pressure reduction, the size and the number of the bubbles may be adjusted.

The reduced pressure mixture 70 may be used for various purposes. As shown in Figure 3, the reduce pressure mixture comprises ozone and water. However, in an alternate embodiment, the reduced pressure mixture may be used for treating another material (in such a case, water 16 may be any fluid which functions as an inert carrier). An example of this could be the use of the reduced pressure mixture 70 as a treatment agent. For example, once again, if gas 50 included an oxidation agent (eg. ozone or peroxide), then the reduced pressure mixture may be fed to a tank containing a material (eg. a chemical compound such as a pesticide, a herbicide or metal) which is to be oxidized. In such a case, the apparatus may be used not to produce drinking water but to permit the safe disposal of toxic material.

It will also be appreciated that two or more gases may be fed into prandtl layer turbine 56. The gases may be reactive with each other and water 16 (or any other carrier fluid) may optionally

be inert. In such a case, the creation of the microbubbles creates an environment in which the gases may intimately mix and react with each other. It will be appreciated by those skilled in the art that other variations of the fluids which are introduced into prandtl layer turbine 56 may be used and that the reduced pressure mixture may be used for various purposes including from polishing a surface for electroplating operations.

It will further be appreciated that a catalyst may be added to the system as shown in Figures 4 and 5. If one member of fluid stream 40 is to react with another portion of fluid stream 40, then the catalyst may be provided to enhance the reaction. The catalyst may be added to the system with fluid stream 40 or, alternately, it may be contained within turbine 56 or expansion zone 72. For example, the catalyst may be in the form of a solid, liquid or a gas and accordingly introduced with either or both of gas 44 or fluid 42. Preferably, the catalyst is in the form of a liquid or a solid. The catalyst may be introduced with fluid 40 via venturi 54 or it may be introduced via a separate port into turbine 56. Plates 58 rotate so as to create a prandtl layer there adjacent. This prandtl layer creates a zone which effectively prevents solid particles from contacting plates 58. Accordingly, a prandtl layer turbine is particularly well adapted for receiving particulate matter, such as catalyst particles. By providing the catalyst as part of fluid stream 40, the catalyst is available for transportation downstream with mixture 70.

It will be appreciated that if the catalyst is used to assist in the reaction between members of fluid stream 40 (as opposed to a reaction involving a material positioned downstream of the apparatus) then the catalyst may be provided in various parts of turbine 56. For example, a catalyst layer 46 may be applied to the surface of plates 58 so as to enhance the reaction of constituents of

fluid stream 40 with each other (see Figure 4). Alternately, or in addition, the catalyst may be provided an expansion zone 72. Referring to Figure 5, a catalyst may be placed as discreet particles 48 which are sufficiently large so as to be maintained in expansion zone 72 as mixture 70 passes there through. For example, expansion zone 12 may be provided with a pair of opposed mesh screens 50 with catalyst particles 48 positioned there between. Catalyst particles 48 and the openings in mesh 50 are sized so as to maintain catalyst particles in a fixed position in expansion zone 72. Alternately, the catalyst particle may be free floating in expansion zone 12. For example, the entry port and exit port to expansion zone 72 may be provided with mesh screens 51 and catalyst 49 may be positioned between screens 51 so as to be able to travel freely with expansion zone 72.

It will be appreciated that if fluid stream 66 is under a sufficiently great pressure as it enters parental layer turbine 56, that the fluid may assist motor 62 in rotating discs 58 or, alternately, turbine 56 may not include a motor 62 and, instead, fluid stream 66 may comprise the necessary motive force to cause plates 58 to rotate. Preferably, plates 58 rotate at an rpm from about 3000 to about 8000 , more preferably from about 3000 to about 5000 and, most preferably, from about 3000 to about 4000.

In the embodiment shown in Figure 5, fluid 42 is drawn through venturi 54 and second venturi 55 by means of a prandtl layer turbine 56. The rotation of the plates 58 causes fluid 42 to be drawn through venturi 54 and through venturi 55. This in turn causes the gas 44 to be drawn from the gas source 80 through tube 82 and into the venturi 54 and also causes gas to be drawn from the gas source 84 through the tube means 86 and into the venturi 55. The gases are preferably drawn into the fluid 42 in such a manner to form small gas bubbles 88 and 90 to form in the respective streams

of the fluid 42 which may be introduced separately into prandtl layer turbine 56.

In the preferred embodiment of Figure 1, when resealable cap 2 is closed the entry of mixture 14 into container 1 increases the pressure in container 1 thereby increasing the amount of gas which will dissolve into the water 16. When the pressure within the container 1 reaches a given pressure (eg. 200 psi) which may be predetermined, the treatment cycle may be terminated by sending a signal to shut off the supply of gas (mixture 14) to container 1. The pressurized fluid may be allowed to stand in container 1 for an extended period of time. When it is desired to empty container 1 (eg. it is desired to use the water) the pressure in container 1 may be released and water 16 dispensed. The unit may include a pressure relief valve and pressure switch 18 which causes the container 1 to be automatically vented to the atmosphere through, for example, an ozone off gas destructor 19 when a predetermined pressure is achieved. At this point, a signal may optionally be sent to the controller 10 through wire 20 indicating that a cycle has been completed thus shutting of the supply of mixture 14 to container 1.

A single charge of water 16 in container 1 may be treated by being exposed to the pressurized gas only once or multiple times. When the endpoint of the process is reached (water 16 has been subjected to the desired number of cycles), the controller 10 may turn off the power to the oxygen rich gas source 3 and to the ozone generator 5 through wires 21 and 22 and signal the user that the process is complete, such as by providing power to the green light 23 by means of wire 24.

Once the water in container 1 is sufficiently treated, cap 2 may be removed, and the water may be removed for use (eg. it may be poured out of container 1). It will of course be appreciated

that the water outlet may be a pipe which is connected to a filter and a dispenser positioned downstream from container 1. A water pump may be included to remove the water and pass it through such a filter. Preferably, the elevated pressure of the ozonation (eg. from air pump 30) is used to dispense, or at least assist in dispensing, the treated water).

An alternate embodiment is shown in Figure 2. In Figure 2, reference numerals common with those in Figure 1 are for like features, and are not described again in detail. In this embodiment, container 1 includes a sensor for monitoring the treatment of the water and sending a signal to controller 10 when the treatment is complete. The sensor may send a signal indicating that the treatment was successfully completed or that the treatment was not successfully completed. The sensor may be any of those known in the art. The specific type of sensor will vary depending upon the liquid being treated in container 1. If the liquid is water, the sensor may be an oxygen reduction potential sensor 26 (i.e. an ORP sensor). The ORP sensor 26 monitors the ORP level and transmits it to the controller 10 through a wire 25. The controller monitors the redox level to determine the endpoint of the water treatment process.

For example, if a preset redox level is maintained for a prescribed time, the desired endpoint is reached and the controller 10 signals to the user that the treatment process is complete by providing power to green light 23 by means of wire 24. If a suitable redox level is not achieved and preferably maintained for a prescribed time, and a preset time elapses, the treatment is ended and the water is not suitable for consumption. In this circumstance, the controller 10 may signal that the process is complete but the water is unsuitable for use by providing power to the red light 27 by means of wire 28.

Alternately, if a suitable redox level is not achieved and maintained for a prescribed time, and a preset time elapses, then controller 10 may cause water 16 to be subjected to one or more treatment cycles until either sensor 26 signals that the treatment is successfully concluded or a preset number of cycles are conducted without success.

It will be appreciated that various mechanisms may be used to determine the end point of a treatment cycle. It will also be appreciated that the apparatus need not include a sensor but may be operated on a different basis (eg. it may be run by a timer). At the end of each cycle, sensor 26 or the timer may send a signal, eg. through controller 10, to pressure relief valve and pressure switch 18 to cause container 1 to be vented to the atmosphere.

In an alternate embodiment also shown in Figure 2, the unreacted gas in a bleed stream of off-gasses 31 from head space 32 is treated to produce a signal which may then be read by ozone sensor 33. Ozone sensor preferably uses an ozone destructor and may double as destructor 19. Such a sensor may operate on various principles.

For example, the signal may be in the form of a temperature change in the off-gas stream. This may be achieved, for example, by subjecting the unreacted gas to a chemical reaction in a reaction zone containing a catalyst to produce heat. In the application of treating water to produce ozone, the sensor contains a catalyst (eg. one or more of manganese dioxide, titanium dioxide, iron oxide, or carbon) for converting ozone to oxygen which produces heat as a by-product. The sensor also includes a temperature sensor, eg. a thermistor, positioned upstream of the catalyst to measure the temperature of the untreated bleed stream and a temperature sensor, eg. a thermistor, to measure the temperature of the treated bleed stream. The temperature difference

is proportional to the amount of ozone converted to oxygen and therefore to the concentration of ozone in head space 32. Sensor 33 will provide a reading of the ozone concentration in the head space by measuring the concentration in the bleed stream and, based on the flow rate into the treatment vessel and the flow rate of the bleed stream, this may be used to calculate the total amount of ozone to which the water was exposed.

By measuring the conversion of ozone to oxygen in sensor 33, great flexibility is obtained in the operation of the treatment cycle. For example, as the volume of water and the anticipated level of contaminants in the water can be predetermined, it is possible to calculate the amount of ozone that will be required to treat the water and to program this information into controller 10. The treatment of the water by ozonation may continue until a predetermined total amount of ozone passes through the water 16 and a portion thereof is converted to oxygen in sensor 33. The predetermined amount of ozone may be measured by the difference in resistance between the two temperature sensors and the time during which the temperature difference is measured.

In the embodiment of Figure 6, the elevated pressure in container 1 is used to dispense the treated water. This embodiment also demonstrates the use of an off gas sensor to control the water treatment cycle.

After passing through the water 16 in the container 1, the gas exits the container 1 through a vent line 120. This removes gas from the head space 32 in container 1 and prevents pressure from building up in the container 1. The vented gas passes through the off gas flow control valve 121 and through tube 122, and into the ozone off gas sensor 123. It then passes through pipe 124, and check valve 41 into tube 43. The vented gas then enters filter 125 and into a treated water vessel (eg a removable carafe) 136 via tube 126 from

where it may pass into the room as oxygen rich gas. Thus, the ozone off gas may serve to disinfect the filter 125 and prevent microbiological growth within the filter. Filter 125 may be any filter known in the water filtration art. Preferably, filter 125 comprises carbon block filter.

It will be appreciated that if container 1 is at least partially sealed, eg. valve 121 is closed or at least partially closed, that pressure will build up in container 1. The increase in pressure in container 1 is beneficial in the treatment of water 16 by mixture 14. In such a case, a bleed stream of the off gases may be passed to sensor 123. Alternately, once the pressure has built up to a desired level in container 1 a steady flow of off gasses may be removed from container 1 to prevent further pressure build up in container 1.

Signals from the ozone sensor 123 are transmitted to the control circuit by any means, for example a wire 129. The control circuit 4 monitors the ozone off gas concentration by means of sensor 123.

Ozone sensor 123 measures the level of ozone in the off gas by any of those known in the art. The ozone level may be measured on an intermittent basis as water 16 is treated but is preferably continuously monitored.

Once sensor 123 detects a value representing the successful completion of the water treatment process, controller 10 detects this and may then shut down the power to the power on light 127 by means of wire 128, the power to the oxygen rich gas source 3 by means of wire 119, and the power to the ozone generator 5 by means of wire 118. It may also cause the water ready light 23 to be illuminated by means of wire 24. Depressing the water dispense button 134 will send a signal to the controller 10 by means of wire 135 and will cause the treated water to be decanted from container 1. Preferably, the water is filtered, such as passing it through a filter

125. This may be achieved by a pump (not shown) or other means known in the art.

In the preferred embodiment of Figure 1, a sufficient amount of pressure is built up in container 1 to cause the water to exit container 1 and to flow through filter 125. To this end, if the treatment cycle is successfully completed, depressing the water dispense button 134 may send a signal to the controller 10 by means of wire 135 which causes the off gas flow control valve 121 to at least partially close, preferably fully close, such as by a mechanical member. Gas, such as from oxygen rich gas source 5, is fed to container 1. This in turn causes pressure to build up within the container 1. When the pressure reaches a preset level (eg. a sufficient amount to cause all of the water in container 1 to pass through filter 125), the water is decanted. In the preferred embodiment, this is achieved by placing a valve 140 which opens at the preset pressure in container 1. Thus the treated water in container 1 will be decanted when the required pressure is reached in container 1. Valve 40 may be a spring loaded check valve. The spring loaded check valve is in communication with the container 1 and the treated water carafe 136. When the check valve is opened, the treated water will flow from the container 1 through tube 143 and through the filter 125 and into the treated water carafe 136. However, it will be appreciated that container 1 may include a pressure sensor which signals controller 10 when the preset pressure is reached and controller 10 may then send a signal to open valve 140. Further, if gas is supplied to container 1 during the dispensing operation, the preset level may be sufficient, together with the supplement gas introduced into container 1 during the dispensing operation, to cause the treated water to pass through filter 125.

In a further embodiment, if the user depresses the dispense button during the delivery of water to the treated water carafe 136 or optionally during the treatment of water 16 in container 1, then another signal is preferably also sent to the controller 10 by means of wire 135. However, since the water treatment is not complete in this case, as a safety feature, the input will cause the off gas flow control valve 121 to be mechanically opened and the oxygen rich gas source 5 to lose power through wire 118 thereby interrupting the dispensing or treatment process. The user may then empty and refill container 1 for another treatment cycle.

Alternately, once a preset amount of time has elapsed during the dispense cycle, the controller 10 may interrupt the flow of gas to container 1 (eg. power to the oxygen rich gas source 5 through wire 118 may be terminated) thereby ending the dispensing process. When the user depresses start button 9 in the future, the mechanical off gas flow control valve 121 will be reset to the starting (eg. open) position for the next cycle to proceed.

It will be appreciated by those skilled in the art that various modifications may be made within the spirit of the present invention, the scope of which is limited only by the claims. For example, a different visual signal may be provided to the user to signal the successful of unsuccessful treatment of the water, and/or an audio signal may be provided.

WE CLAIM:

1. A method for treating a liquid with a gas in a sealed vessel comprising the steps of:
(a) introducing the gas into the sealed vessel;
(b) promoting the dissolution of the gas in the liquid by increasing the pressure in the vessel; and,
(c) reducing the pressure after the pressure in the vessel reaches a predetermined level.

2. The method as claimed in claim 1 further comprising the steps, after step (c), of:
(d) repeating steps (a) through (c) until the liquid is treated to a desired level; and,
(e) signalling a user that the treatment is complete.

3. The method as claimed in claim 1 wherein the pressure in the sealed vessel is increased by supplying pressurized gas to the vessel.

4. The method as claimed in claim 3 wherein the gas comprises ozone and the method additionally comprises the step of, prior to step (a), generating ozone in an ozone generator.

5. The method as claimed in claim 4 additionally comprising the step of, prior to generating ozone, concentrating a source of oxygen to produce an oxygen enriched stream which is supplied to the ozone generator.

6. The method as claimed in claim 1 wherein step (a) comprises introducing the gas into the sealed vessel by passing the

gas through a disperser positioned to finely disperse the gas in the liquid.

7. The method as claimed in claim 3 wherein the liquid comprises water to be treated for human consumption and the gas comprises ozone and the method comprises a method for treating water.

8. The method as claimed in claim 1 further comprising the step, after step (c), of signalling a user that the treatment is complete.

9. The method as claimed in claim 1 further comprising the step of monitoring the treatment of the liquid and signalling the user that the liquid has not been fully treated.

10. A method for treating a liquid in a sealed vessel, with a gas, comprising the steps of:

(a) introducing the gas into the vessel;

(b) promoting the dissolution of the gas in the liquid by increasing the pressure in the vessel; and

(c) monitoring the treatment of the liquid and reducing the pressure after the treatment of the liquid in the vessel reaches a predetermined level.

11. The method as claimed in claim 10 further comprising the steps, after step (c), of signalling a user that the treatment is complete.

12. The method as claimed in claim 10 wherein the pressure in the sealed vessel is increased by supplying pressurized gas to the vessel.

13. The method as claimed in claim 10 wherein step (a) comprises introducing the gas into the sealed vessel by passing the gas through a disperser positioned to finely disperse the gas in the liquid.

14. The method as claimed in claim 10 wherein the gas comprises ozone and the method further comprises the step of, prior to step (a), generating ozone in an ozone generator.

15. The method as claimed in claim 14 additionally comprising the step of, prior to generating ozone, concentrating a source of oxygen to provide concentrated oxygen which is supplied to the ozone generator.

16. The method as claimed in claim 10 wherein the liquid comprises water to be treated for human consumption and the gas comprises ozone and the method comprises a method for treating water.

17. The method as claimed in claim 10 further comprising the step of signalling the user that the liquid has not been fully treated.

18. An apparatus for treating a liquid with a gas comprising:

(a) a vessel having at least one inlet port for introducing the gas and the liquid into the vessel and, a gas outlet port for removing gas from the vessel;

(b) a pressurized source of the gas for treating the liquid in communication with the inlet port;

(c) a disperser for introducing the gas into the liquid in the vessel; and

(d) a valve for reducing pressure in the vessel after the gas in the vessel reaches a predetermined pressure.

19. The apparatus as claimed in claim 18 further comprising a check valve located between the inlet port and the source of pressurized gas, to prevent fluid from flowing upstream to the source of pressurized gas.

20. The apparatus as claimed in claim 18 wherein the gas comprises ozone and the liquid comprises water.

21. The apparatus as claimed in claim 20 wherein the source of pressurized gas comprises an ozone generator.

22. The apparatus as claimed in claim 21 further comprising an oxygen concentrator for supplying an oxygen enriched stream to the ozone generator.

23. The apparatus as claimed in claim 18 wherein the vessel is removable from the apparatus.

24. The apparatus as claimed in claim 18 further comprising a signal to signal the user when the treatment reaches a predetermined level.

25. The apparatus as claimed in claim 18 further comprising a signal to signal the user when the treatment is successfully completed.

26. An apparatus for treating a liquid with a gas comprising:

(a) a vessel having at least one inlet port for introducing the gas and the liquid into the vessel and a gas outlet port for removing gas from the vessel;

(b) a pressurized source of the gas in communication with the inlet port;

(c) a disperser for introducing the gas into liquid in the vessel; and,

(d) a sensor for monitoring the treatment of the liquid in the vessel and signalling a user when the treatment reaches a predetermined level.

27. The apparatus as claimed in claim 26 further comprising a valve for releasing pressure from the vessel when the treatment reaches a predetermined level.

28. The apparatus as claimed in claim 26 further comprising a check valve located between the inlet port and the source of pressurized gas, to prevent fluid from flowing upstream to the source of pressurized gas.

29. The apparatus as claimed in claim 26 wherein the gas comprises ozone and the liquid comprises water.

30. The apparatus as claimed in claim 29 wherein the source of pressurized gas comprises an ozone generator.

31. The apparatus as claimed in claim 30 further comprising an oxygen concentrator for supplying an oxygen enriched stream to the ozone generator.

32. The apparatus as claimed in claim 26 wherein the vessel is removable from the apparatus.

33. The apparatus as claimed in claim 18 further comprising a signal to signal the user when the treatment is successfully completed.

34. A domestic method of treating a liquid comprising water with a gas comprising ozone, the method comprising the steps of:

(a) providing the liquid in a treatment vessel;

(b) introducing the gas into the vessel to treat the liquid in the treatment vessel to obtain treated liquid;

(c) increasing the pressure in the treatment vessel; and

(d) utilizing the increased pressure in the treatment vessel to dispense the treated liquid from the treatment vessel.

35. The method as claimed in claim 343 further comprising the step of venting at least a portion of the gas from the treatment vessel during step (b).

36. The method as claimed in claim 35 wherein the pressure in the treatment vessel is increased by reducing the amount of gas which is being vented from the treatment vessel.

37. The method as claimed in claim 34 further comprising the step of passing the treated liquid through a filter located downstream from the treatment vessel during step (d).

38. The method as claimed in claim 37 further comprising the step of venting at least a portion of the gas from the treatment vessel during step (b) and passing at least a portion of the vented gas through the filter.

39. The method as claimed in claim 34 further comprising the step of automatically dispensing the treated water when the pressure in the treatment vessel reaches a preset level.

40. A domestic water purifier for treating a liquid comprising water with a gas comprising ozone, the apparatus comprising:

(a) retaining means for retaining the liquid during a treatment cycle of the liquid with the gas;

(b) means for introducing the gas under pressure into the retaining means to obtain treated liquid;

(c) venting means for removing off gas from the retaining means; and,

(d) means for increasing the pressure in the retaining means by the end of a treatment cycle.

41. The apparatus as claimed in claim 40 further comprising dispensing means for automatically removing treated

liquid from the retaining means during a dispensing cycle when the pressure in the retaining means reaches a predetermined level.

42. The apparatus as claimed in claim 40 further comprising a filter means positioned downstream from the retaining means and the predetermined pressure level is determined based on the pressure required to cause the treated water to flow through the filter means.

43. The apparatus as claimed in claim 42 further comprising a means for conveying the off gas through the filter means.

44. The apparatus as claimed in claim 41 wherein at the end of the treatment cycle the venting means is interrupted to increase the pressure in the retaining means to the predetermined level.

45. The apparatus as claimed in claim 40 further comprising means for actuating the dispensing cycle and means for preventing the liquid to be dispensed from the retaining means if a predetermined level of treatment of the liquid is not achieved.

46. A domestic water purifier for treating a liquid comprising water with a gas comprising ozone, the apparatus comprising:

(a) a housing;

(b) at least one inlet port for introducing the gas and at least one liquid to the housing;

(c) a plurality of spaced apart members rotatably mounted within the housing; and,

(d) a drive member for rotating the spaced apart members at a rate sufficient for dissolving at least a portion of the gas into the liquid to form a liquid/gas mixture and at a rate sufficient to maintain a laminar flow in a boundary layer adjacent the spaced apart members.

47. The mixing apparatus as claimed in claim 46 further comprising a pressure reduction zone downstream from the spaced apart members.

48. The mixing apparatus as claimed in claim 47 wherein the gas/liquid mixture is subjected to an elevated pressure in the housing and the pressure to which the gas/liquid mixture is subjected is rapidly reduced as it enters the pressure reduction zone.

49. The mixing apparatus as claimed in claim 46 wherein the inlet port includes a member for dividing the gas into bubbles in the fluid.

50. The apparatus as claimed in claim 46 wherein the plurality of spaced apart members rotatably mounted within the housing are part of a prandtl layer turbine.

51. A mixing apparatus comprising:

(a) means for creating a boundary layer adjacent a plurality of spaced apart members rotatably mounted within a housing;

(b) means for introducing at least one gas and at least one liquid to the housing;

(c) a plurality of spaced apart members rotatably mounted within the housing; and,

(d) means for rotating the spaced apart members at a rate sufficient for dissolving at least a portion of the gas into the liquid to form a liquid/gas mixture.

52. The mixing apparatus as claimed in claim 51 further comprising means for rapidly depressurizing the gas/liquid mixture.

53. The mixing apparatus as claimed in claim 51 wherein a catalyst reactive with at least one of the gas and the liquid is applied to at least a portion of one of the spaced apart members.

54. The mixing apparatus as claimed in claim 52 further comprising means for contacting the gas/liquid mixture with a catalyst reactive with at least one of the gas and the liquid when the gas/liquid mixture has been subjected to a reduced pressure.

55. The mixing apparatus as claimed in claim 54 wherein the at least one gas comprises ozone and the at least one liquid comprises water and the mixing apparatus is used in the treatment of water.

56. The mixing apparatus as claimed in claim 51 wherein at least two gases are introduced into the housing and the at least one liquid is inert whereby the at least one liquid is a media for the dissolution of one of the gases into another of the gases or for the reaction of the gases with each other.

57. The mixing apparatus as claimed in claim 51 wherein a catalyst is introduced into the mixing apparatus.

58. The mixing apparatus as claimed in claim 57 wherein the catalyst is a liquid or a solid form.

59. The mixing apparatus as claimed in claim 51 wherein the means for introducing at least one gas and at least one liquid to the housing comprises means for dividing the gas into bubbles in the fluid.

60. A method for treating water comprising introducing at least one oxidizing gas and water into a prandtl layer turbine and passing the gas and the water through the prandtl layer turbine to obtain a water/gas mixture.

61. The method as claimed in claim 60 further comprising passing the water/gas mixture through a pressure reduction zone to obtain a water/gas mixture at a reduced pressure.

62. The method as claimed in claim 60 further comprising exposing at least one of the water and the gas to a catalyst in the housing.

63. The method as claimed in claim 60 further comprising exposing at least one of the water and the gas to a catalyst in the pressure reduction zone.

64. The method as claimed in claim 60 further comprising introducing a catalyst into the mixing apparatus together with the gas and the water.

65. The method as claimed in claim 60 further comprising separately introducing the gas and the water into the housing.

66. The method as claimed in claim 60 further comprising mixing the gas and the water to create gas bubbles in the water prior to introducing the water and the gas into the prandtl layer turbine.

67. A method for mixing a liquid and a gas comprising the step of subjecting at least one gas and at least one liquid to an elevated pressure created at least in part by a plurality of rotating spaced apart members to obtain a liquid/gas mixture.

68. The method as claimed in claim 67 further comprising the step of treating the liquid/gas mixture to obtain a solution containing microbubbles.

69. The method as claimed in claim 67 further comprising the step of rapidly depressurizing the liquid/gas mixture.

70. The method as claimed in claim 67 further comprising the step of reacting at least one of the liquid and the gas with a catalyst.

71. The method as claimed in claim 68 further comprising the step of treating the solution with a catalyst.

72. The method as claimed in claim 68 wherein the at least one gas comprises ozone and the at least one liquid comprises water and the method comprises a process for the treatment of water.

73. The method as claimed in claim 67 wherein at least two gases are subjected to the elevated pressure conditions and the method comprises a process for the dissolution of one of the gases into another of the gases or for the reaction of the gases with each other.

74. The method as claimed in claim 70 further comprising the step of introducing the catalyst into the rotating spaced apart members.

75. The method as claimed in claim 70 further comprising the step of separately introducing one of the at least one gas and the liquid into the rotating spaced apart members.

76. The method as claimed in claim 67 further comprising the step of introducing a mixture of gas bubbles in the liquid to the rotating spaced apart members.

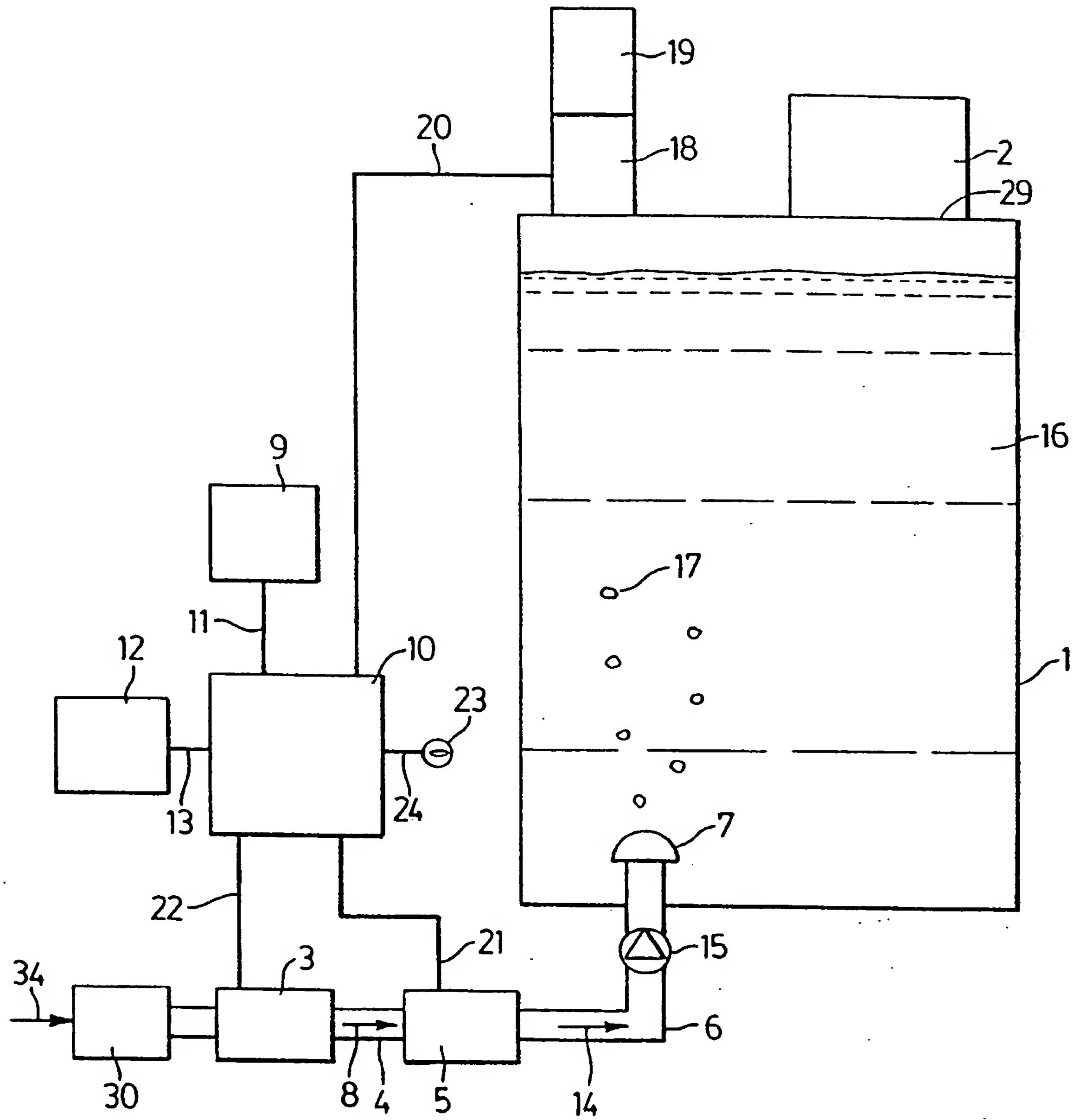



FIG. 1

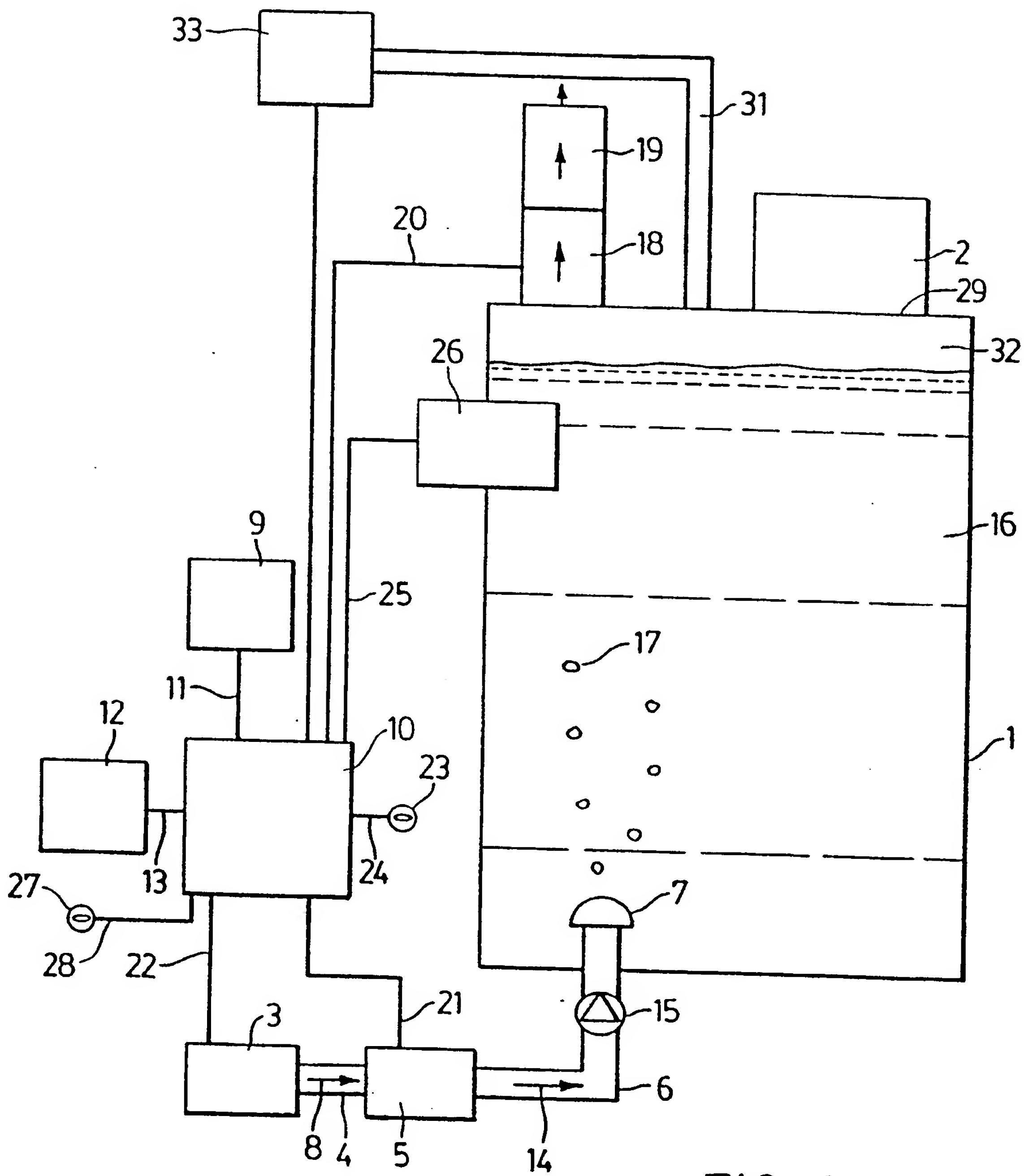

33
31
19
18
20
2
29
26
32
16
9
25
17
11
12
10
23
1
27
13
24
7
28
22
21
15
3
6
8
4
5
14

FIG. 2

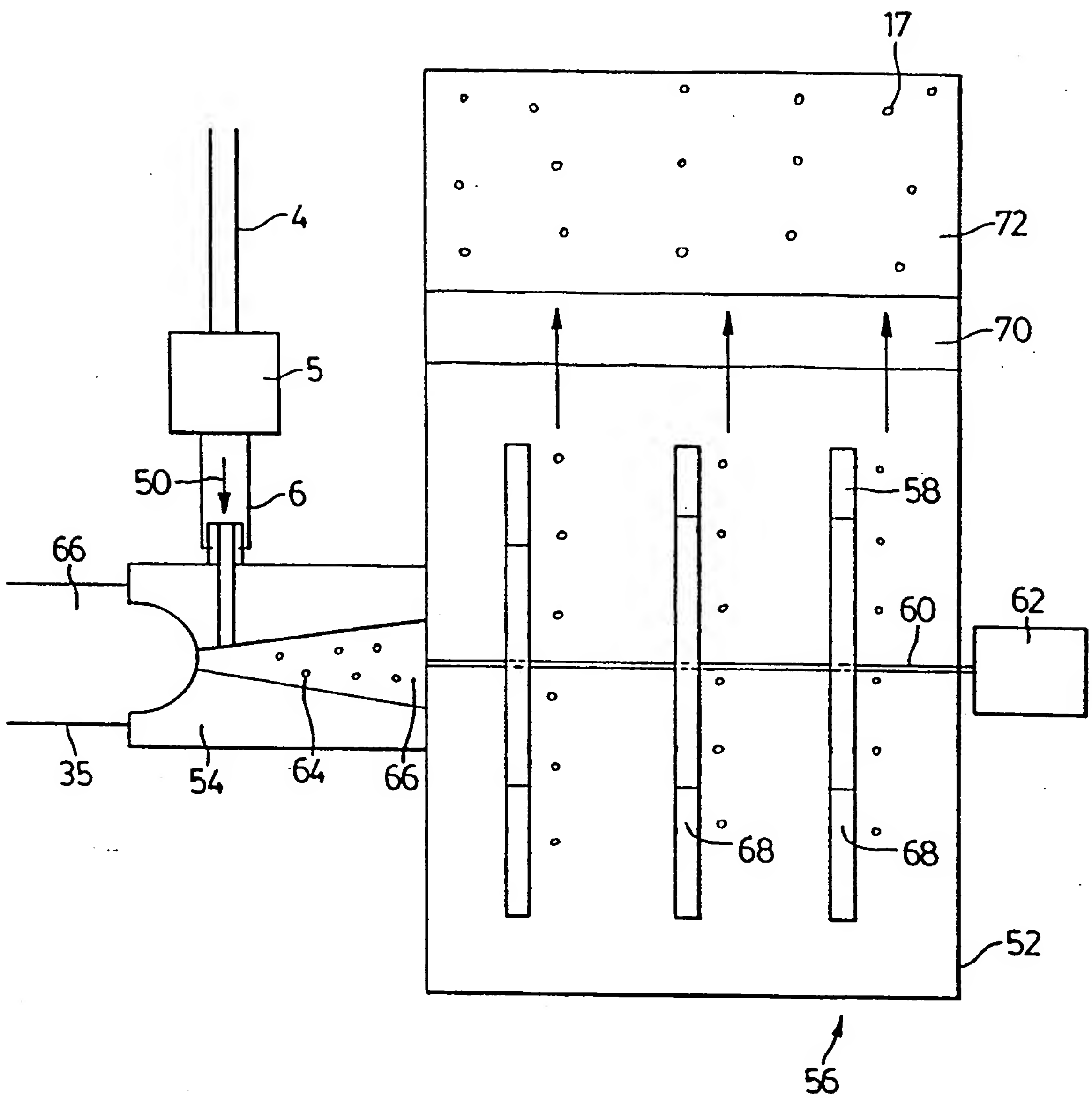



FIG. 3

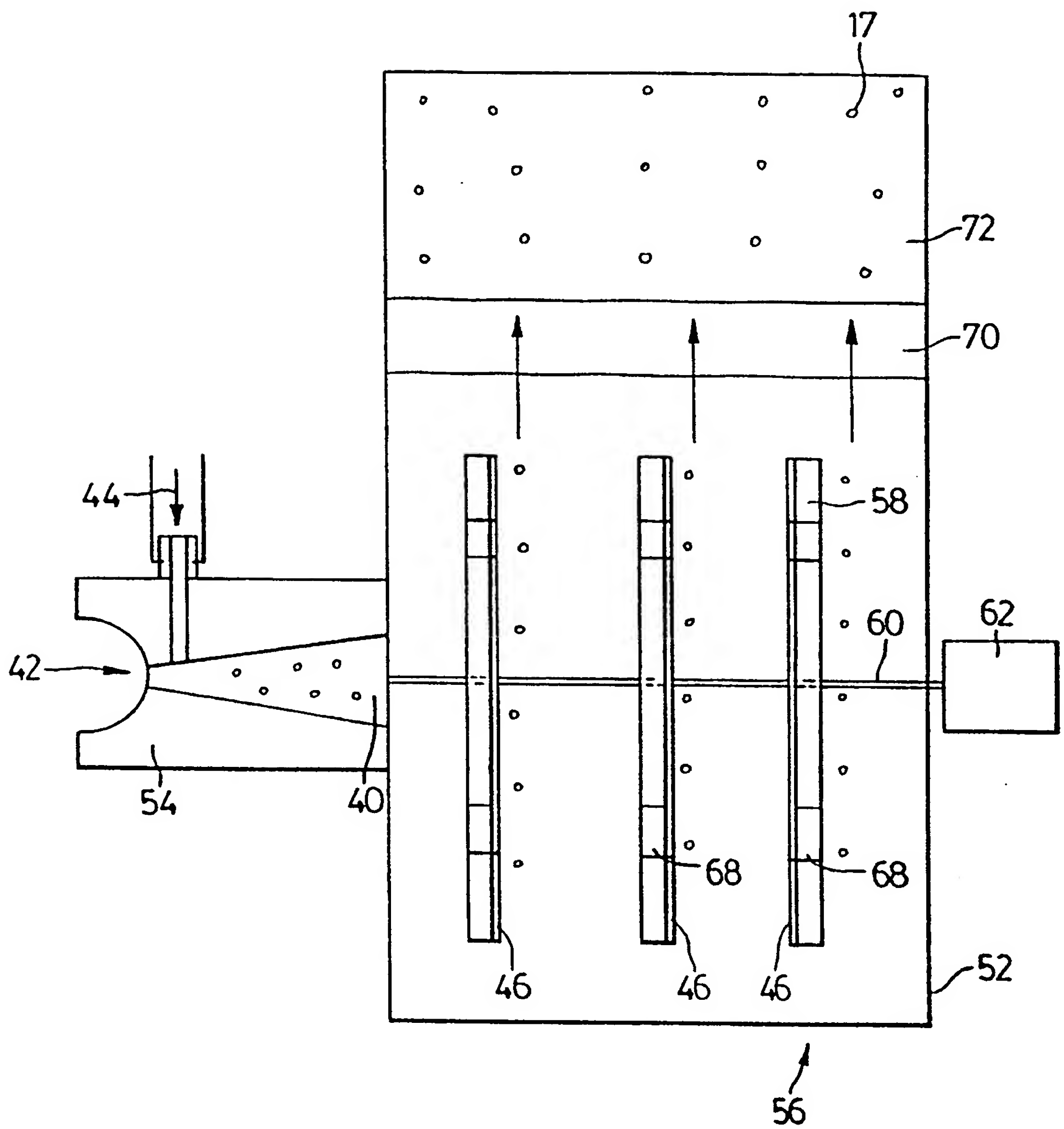



FIG. 4

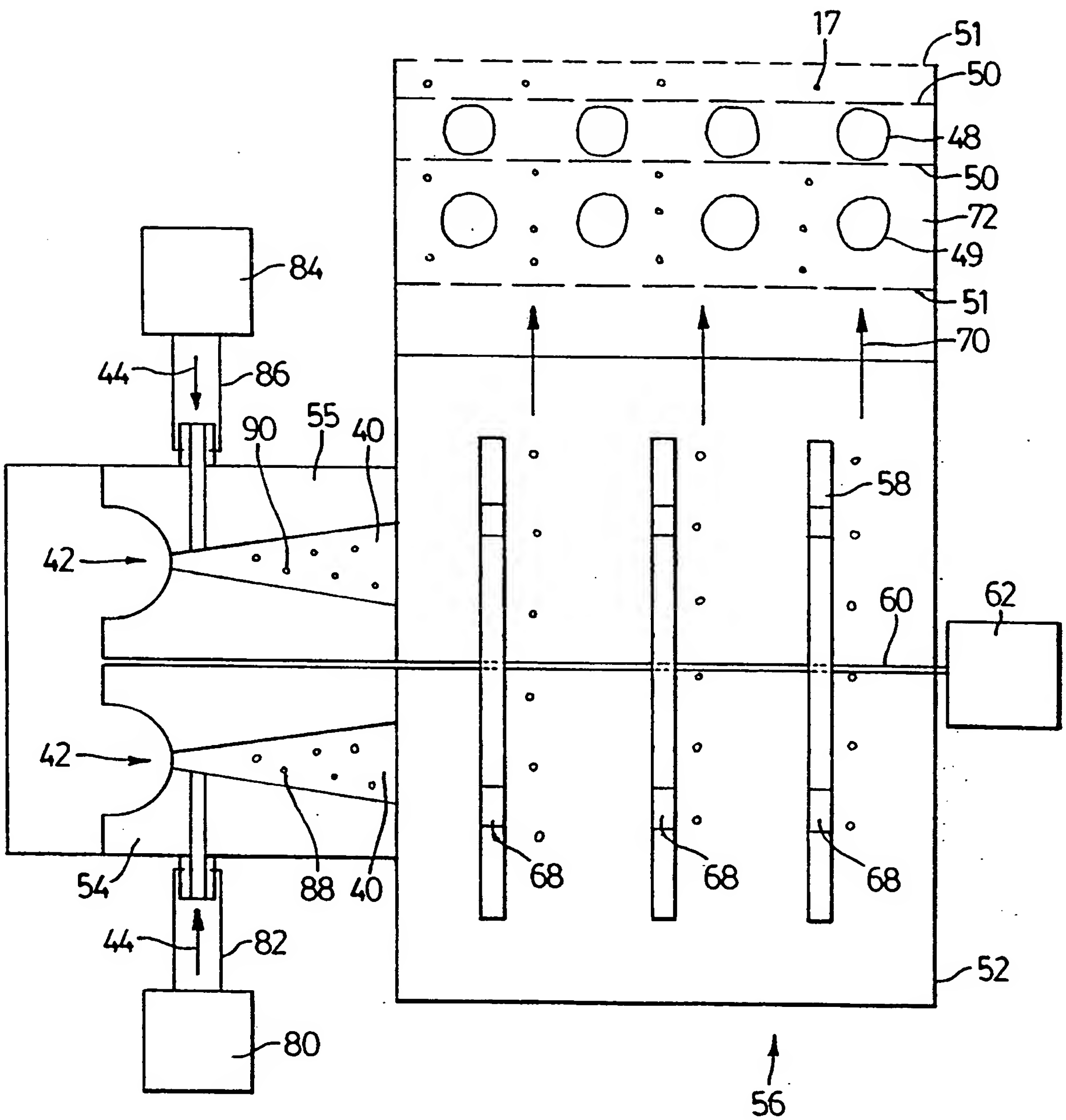

17
51
50
48
50
72
49
51
70
84
44
86
90
55
40
58
42
60
62
42
54
88
40
68
68
68
44
82
52
80
56

FIG. 5

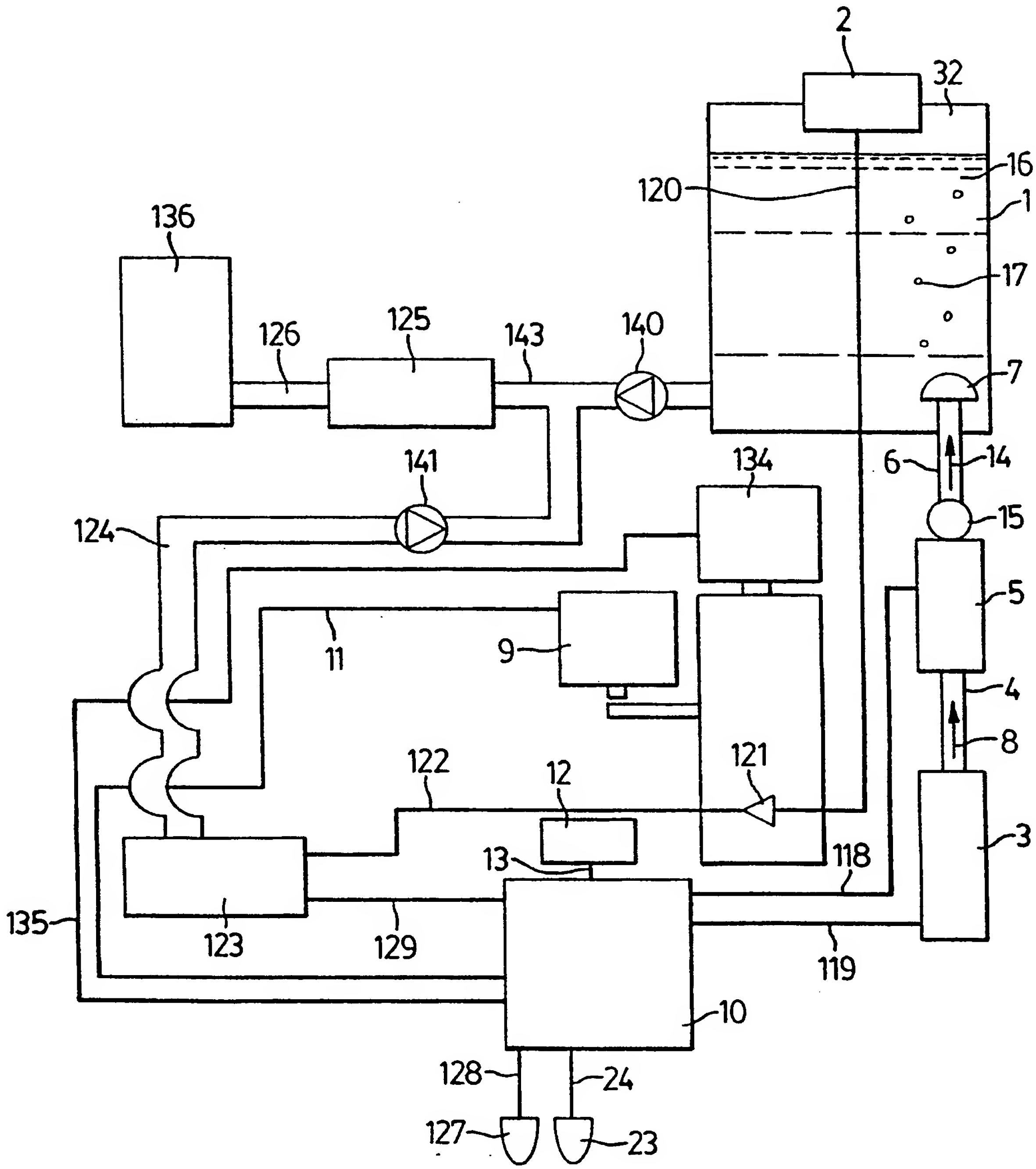

2
32
16
120
1
136
17
126
125
143
140
7
141
134
6
14
124
15
5
11
9
4
8
122
12
121
3
13
118
135
123
129
119
10
128
24
127
23

FIG. 6

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

# INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : C02F 1/78, B01F 7/10

A3

(11) International Publication Number: WO 00/27760

(43) International Publication Date: 18 May 2000 (18.05.00)

(21) International Application Number: PCT/CA99/01050

(22) International Filing Date: 8 November 1999 (08.11.99)

(30) Priority Data:

| | | |
|---|---|---|
| 2,253,689 | 9 November 1998 (09.11.98) | CA |
| 2,253,101 | 9 November 1998 (09.11.98) | CA |
| 2,253,079 | 9 November 1998 (09.11.98) | CA |
| 09/240,619 | 1 February 1999 (01.02.99) | US |
| 09/240,617 | 1 February 1999 (01.02.99) | US |
| 09/240,615 | 1 February 1999 (01.02.99) | US |

(63) Related by Continuation (CON) or Continuation-in-Part (CIP) to Earlier Applications

| | |
|---|---|
| US | 09/240,617 (CIP) |
| Filed on | 1 February 1999 (01.02.99) |
| US | 09/240,615 (CIP) |
| Filed on | 1 February 1999 (01.02.99) |
| US | 09/240,619 (CIP) |
| Filed on | 1 February 1999 (01.02.99) |

(71) Applicant (*for all designated States except US*): FANTOM TECHNOLOGIES INC. [CA/CA]; 1110 Hansler Road, Welland, Ontario L3B 5S1 (CA).

(72) Inventors; and

(75) Inventors/Applicants (*for US only*): CONRAD, Wayne, Ernest [CA/CA]; 27 King Street, Hampton, Ontario L0B 1J0 (CA). CONRAD, Helmut, Gerhard [CA/CA]; 27 King Street, Hampton, Ontario L0B 1J0 (CA). PHILLIPS, Richard, Stanley [CA/CA]; 24 Devondale Street, Courtice, Ontario L1E 1S1 (CA).

(74) Agent: BERESKIN & PARR; 40th floor, 40 King Street West, Toronto, Ontario M5H 3Y2 (CA).

(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

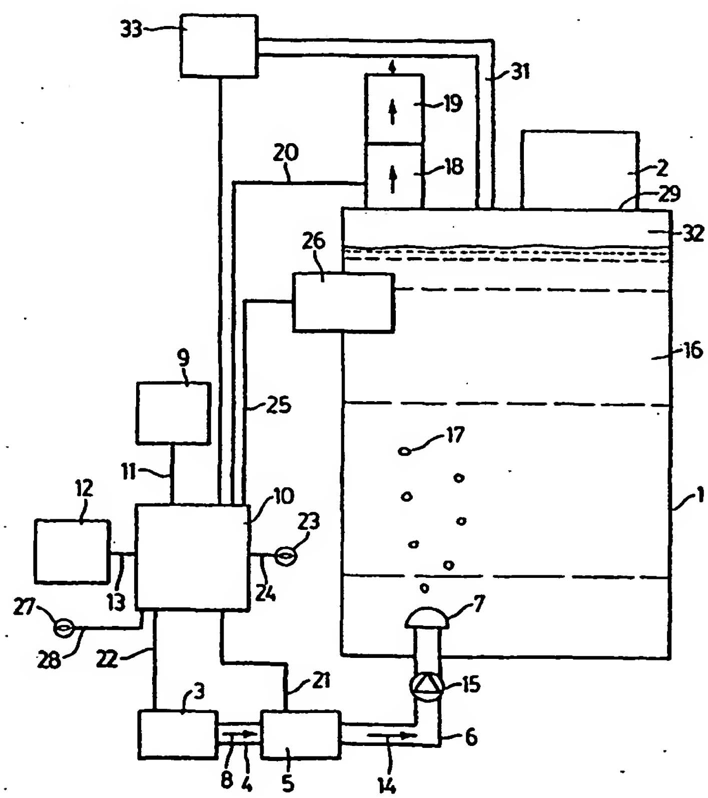
**Published**
*With international search report.*

(88) Date of publication of the international search report: 31 August 2000 (31.08.00)

(54) Title: PRESSURE SWING CONTACTOR FOR THE TREATMENT OF A LIQUID WITH A GAS

(57) Abstract

A residential method for treating water with an ozidizing gas operates under elevated pressure. The elevated pressure is obtained by means of a pressurized oxidizing gas source (e.g. an air pump) or a prandtl layer turbine. The elevated pressure of the treated water is optionally used to dispense the treated water. The prandtl layer turbine may be used to obtain particularly fine bubbles of a gas (e.g. bubbles from about $1\mu$ to about $20\mu$ in diameter) in a liquid.



*FOR THE PURPOSES OF INFORMATION ONLY*

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

| | |
|---|---|
| AL | Albania |
| AM | Armenia |
| AT | Austria |
| AU | Australia |
| AZ | Azerbaijan |
| BA | Bosnia and Herzegovina |
| BB | Barbados |
| BE | Belgium |
| BF | Burkina Faso |
| BG | Bulgaria |
| BJ | Benin |
| BR | Brazil |
| BY | Belarus |
| CA | Canada |
| CF | Central African Republic |
| CG | Congo |
| CH | Switzerland |
| CI | Côte d'Ivoire |
| CM | Cameroon |
| CN | China |
| CU | Cuba |
| CZ | Czech Republic |
| DE | Germany |
| DK | Denmark |
| EE | Estonia |
| ES | Spain |
| FI | Finland |
| FR | France |
| GA | Gabon |
| GB | United Kingdom |
| GE | Georgia |
| GH | Ghana |
| GN | Guinea |
| GR | Greece |
| HU | Hungary |
| IE | Ireland |
| IL | Israel |
| IS | Iceland |
| IT | Italy |
| JP | Japan |
| KE | Kenya |
| KG | Kyrgyzstan |
| KP | Democratic People's Republic of Korea |
| KR | Republic of Korea |
| KZ | Kazakstan |
| LC | Saint Lucia |
| LI | Liechtenstein |
| LK | Sri Lanka |
| LR | Liberia |
| LS | Lesotho |
| LT | Lithuania |
| LU | Luxembourg |
| LV | Latvia |
| MC | Monaco |
| MD | Republic of Moldova |
| MG | Madagascar |
| MK | The former Yugoslav Republic of Macedonia |
| ML | Mali |
| MN | Mongolia |
| MR | Mauritania |
| MW | Malawi |
| MX | Mexico |
| NE | Niger |
| NL | Netherlands |
| NO | Norway |
| NZ | New Zealand |
| PL | Poland |
| PT | Portugal |
| RO | Romania |
| RU | Russian Federation |
| SD | Sudan |
| SE | Sweden |
| SG | Singapore |
| SI | Slovenia |
| SK | Slovakia |
| SN | Senegal |
| SZ | Swaziland |
| TD | Chad |
| TG | Togo |
| TJ | Tajikistan |
| TM | Turkmenistan |
| TR | Turkey |
| TT | Trinidad and Tobago |
| UA | Ukraine |
| UG | Uganda |
| US | United States of America |
| UZ | Uzbekistan |
| VN | Viet Nam |
| YU | Yugoslavia |
| ZW | Zimbabwe |

# INTERNATIONAL SEARCH REPORT

Inte, .nal Application No
PCT/CA 99/01050

**A. CLASSIFICATION OF SUBJECT MATTER**
IPC 7 C02F1/78 B01F7/10

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 C02F B01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category ° | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | US 3 699 776 A (RAUS JULIUS LA) 24 October 1972 (1972-10-24) | 1,3-7, 18-23 |
| Y | the whole document | 2,8-17, 24-33 |
| Y | US 5 683 576 A (OLSEN PHILIP C) 4 November 1997 (1997-11-04) column 4, line 66 -column 5, line 15 column 7, line 4-25 | 2,8-17, 24-33 |
| X | US 5 213 773 A (BURRIS WILLIAM A) 25 May 1993 (1993-05-25) | 1,2, 6-11, 13-38, 40-43,45 |
| A | column 2, line 65 -column 3, line 50 column 4, line 24-41 column 5, line 19-58; figures | 3-5,12 |

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 8 June 2000 | 20.06.00 |

| Name and mailing address of the ISA | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016 | Gruber, M |

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

| Category ° | Citation of document, with indication,where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | PATENT ABSTRACTS OF JAPAN vol. 1998, no. 13, 30 November 1998 (1998-11-30) & JP 10 216752 A (HITACHI LTD), 18 August 1998 (1998-08-18) abstract | 46-55, 57-65, 67-72, 74-76 |
| X | PATENT ABSTRACTS OF JAPAN vol. 006, no. 102 (C-107), 11 June 1982 (1982-06-11) & JP 57 032789 A (MITSUBISHI ELECTRIC CORP), 22 February 1982 (1982-02-22) abstract | 46,47, 49-52, 59,60, 65, 67-69, 72,76 |
| X | PATENT ABSTRACTS OF JAPAN vol. 012, no. 075 (C-480), 9 March 1988 (1988-03-09) & JP 62 213890 A (MITSUTOSHI MATSUOKA), 19 September 1987 (1987-09-19) abstract | 46,47, 49-52, 59,60, 65, 67-69, 72,76 |
| A | PATENT ABSTRACTS OF JAPAN vol. 1995, no. 04, 31 May 1995 (1995-05-31) & JP 07 008976 A (MEIDENSHA CORP), 13 January 1995 (1995-01-13) abstract | 1-33 |
| A | US 4 019 986 A (BURRIS WILLIAM ALAN ET AL) 26 April 1977 (1977-04-26) claims | 1-33 |
| A | US 4 453 953 A (TANAKA MASAAKI ET AL) 12 June 1984 (1984-06-12) the whole document | 1-33 |
| A | PATENT ABSTRACTS OF JAPAN vol. 1996, no. 02, 29 February 1996 (1996-02-29) & JP 07 275873 A (MEIDENSHA CORP), 24 October 1995 (1995-10-24) abstract | 1-33 |

4

# INTERNATIONAL SEARCH REPORT

**Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)**

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [ ] Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. [ ] Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. [X] As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

**Remark on Protest**

[ ] The additional search fees were accompanied by the applicant's protest.

[X] No protest accompanied the payment of additional search fees.

**FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210**

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-33

   Methode and apparatus for controlling a mixing process of a gas with a liquid under pressure.

2. Claims: 34-45

   Methode and apparatus for for dispensing a liquid from an apparatus in an efficient and energy saving manner by using the pressure existent in the apparatus after completion of a mixing process of the liquid with a gas.

3. Claims: 46-76

   Methode and an apparatus for mixing a liquid with a gas in an apparatus under conditions for improved dissolution of the gas into the liquid, e.g. pressure and/or shearing forces created by a plurality of rotatably mounted spaced apart members.

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/CA 99/01050

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| US 3699776 A | 24-10-1972 | NONE | |
| US 5683576 A | 04-11-1997 | NONE | |
| US 5213773 A | 25-05-1993 | US 5082558 A | 21-01-1992 |
| | | US 5207993 A | 04-05-1993 |
| | | CA 2130181 A | 16-09-1993 |
| | | EP 0630267 A | 28-12-1994 |
| | | WO 9317725 A | 16-09-1993 |
| | | US 5422043 A | 06-06-1995 |
| | | AU 645465 B | 13-01-1994 |
| | | AU 8648391 A | 30-03-1992 |
| | | CA 2089887 A,C | 01-03-1992 |
| | | DE 69106716 D | 23-02-1995 |
| | | DE 69106716 T | 14-06-1995 |
| | | EP 0546089 A | 16-06-1993 |
| | | JP 6501112 T | 27-01-1994 |
| | | WO 9204098 A | 19-03-1992 |
| | | CA 2106495 A,C | 19-09-1992 |
| | | DE 69229111 D | 10-06-1999 |
| | | DE 69229111 T | 28-10-1999 |
| | | EP 0576563 A | 05-01-1994 |
| | | EP 0893126 A | 27-01-1999 |
| | | EP 0893127 A | 27-01-1999 |
| | | WO 9216241 A | 01-10-1992 |
| JP 10216752 A | 18-08-1998 | NONE | |
| JP 57032789 A | 22-02-1982 | NONE | |
| JP 62213890 A | 19-09-1987 | NONE | |
| JP 07008976 A | 13-01-1995 | NONE | |
| US 4019986 A | 26-04-1977 | NONE | |
| US 4453953 A | 12-06-1984 | JP 1346718 C | 13-11-1986 |
| | | JP 57188404 A | 19-11-1982 |
| | | JP 61011882 B | 05-04-1986 |
| | | JP 1346719 C | 13-11-1986 |
| | | JP 57188405 A | 19-11-1982 |
| | | JP 61011883 B | 05-04-1986 |
| | | JP 1003157 B | 19-01-1989 |
| | | JP 1538809 C | 16-01-1990 |
| | | JP 57187094 A | 17-11-1982 |
| | | DE 3149681 A | 02-12-1982 |
| JP 07275873 A | 24-10-1995 | NONE | |

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : C02F 1/78, B01F 7/10 — A3

(11) International Publication Number: WO 00/27760

(43) International Publication Date: 18 May 2000 (18.05.00)

(21) International Application Number: PCT/CA99/01050

(22) International Filing Date: 8 November 1999 (08.11.99)

(30) Priority Data:

| | | |
|---|---|---|
| 2,253,689 | 9 November 1998 (09.11.98) | CA |
| 2,253,101 | 9 November 1998 (09.11.98) | CA |
| 2,253,079 | 9 November 1998 (09.11.98) | CA |
| 09/240,619 | 1 February 1999 (01.02.99) | US |
| 09/240,617 | 1 February 1999 (01.02.99) | US |
| 09/240,615 | 1 February 1999 (01.02.99) | US |

(63) Related by Continuation (CON) or Continuation-in-Part (CIP) to Earlier Applications

| | |
|---|---|
| US | 09/240,617 (CIP) |
| Filed on | 1 February 1999 (01.02.99) |
| US | 09/240,615 (CIP) |
| Filed on | 1 February 1999 (01.02.99) |
| US | 09/240,619 (CIP) |
| Filed on | 1 February 1999 (01.02.99) |

(71) Applicant (*for all designated States except US*): FANTOM TECHNOLOGIES INC. [CA/CA]; 1110 Hansler Road, Welland, Ontario L3B 5S1 (CA).

(72) Inventors; and
(75) Inventors/Applicants (*for US only*): CONRAD, Wayne, Ernest [CA/CA]; 27 King Street, Hampton, Ontario L0B 1J0 (CA). CONRAD, Helmut, Gerhard [CA/CA]; 27 King Street, Hampton, Ontario L0B 1J0 (CA). PHILLIPS, Richard, Stanley [CA/CA]; 24 Devondale Street, Courtice, Ontario L1E 1S1 (CA).

(74) Agent: BERESKIN & PARR; 40th floor, 40 King Street West, Toronto, Ontario M5H 3Y2 (CA).

(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

**Published**
*With international search report*
*With amended claims.*

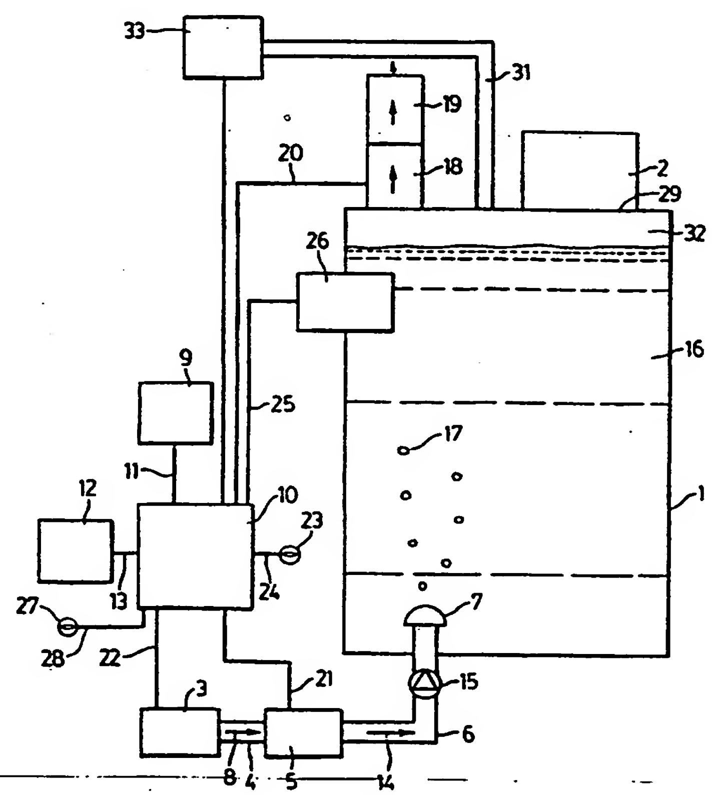
(88) Date of publication of the international search report: 31 August 2000 (31.08.00)

Date of publication of the amended claims: 19 October 2000 (19.10.00)

(54) Title: PRESSURE SWING CONTACTOR FOR THE TREATMENT OF A LIQUID WITH A GAS

(57) Abstract

A residential method for treating water with an ozidizing gas operates under elevated pressure. The elevated pressure is obtained by means of a pressurized oxidizing gas source (e.g. an air pump) or a prandtl layer turbine. The elevated pressure of the treated water is optionally used to dispense the treated water. The prandtl layer turbine may be used to obtain particularly fine bubbles of a gas (e.g. bubbles from about 1$\mu$ to about 20$\mu$ in diameter) in a liquid.



## *FOR THE PURPOSES OF INFORMATION ONLY*

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

| | |
|---|---|
| AL | Albania |
| AM | Armenia |
| AT | Austria |
| AU | Australia |
| AZ | Azerbaijan |
| BA | Bosnia and Herzegovina |
| BB | Barbados |
| BE | Belgium |
| BF | Burkina Faso |
| BG | Bulgaria |
| BJ | Benin |
| BR | Brazil |
| BY | Belarus |
| CA | Canada |
| CF | Central African Republic |
| CG | Congo |
| CH | Switzerland |
| CI | Côte d'Ivoire |
| CM | Cameroon |
| CN | China |
| CU | Cuba |
| CZ | Czech Republic |
| DE | Germany |
| DK | Denmark |
| EE | Estonia |
| ES | Spain |
| FI | Finland |
| FR | France |
| GA | Gabon |
| GB | United Kingdom |
| GE | Georgia |
| GH | Ghana |
| GN | Guinea |
| GR | Greece |
| HU | Hungary |
| IE | Ireland |
| IL | Israel |
| IS | Iceland |
| IT | Italy |
| JP | Japan |
| KE | Kenya |
| KG | Kyrgyzstan |
| KP | Democratic People's Republic of Korea |
| KR | Republic of Korea |
| KZ | Kazakstan |
| LC | Saint Lucia |
| LI | Liechtenstein |
| LK | Sri Lanka |
| LR | Liberia |
| LS | Lesotho |
| LT | Lithuania |
| LU | Luxembourg |
| LV | Latvia |
| MC | Monaco |
| MD | Republic of Moldova |
| MG | Madagascar |
| MK | The former Yugoslav Republic of Macedonia |
| ML | Mali |
| MN | Mongolia |
| MR | Mauritania |
| MW | Malawi |
| MX | Mexico |
| NE | Niger |
| NL | Netherlands |
| NO | Norway |
| NZ | New Zealand |
| PL | Poland |
| PT | Portugal |
| RO | Romania |
| RU | Russian Federation |
| SD | Sudan |
| SE | Sweden |
| SG | Singapore |
| SI | Slovenia |
| SK | Slovakia |
| SN | Senegal |
| SZ | Swaziland |
| TD | Chad |
| TG | Togo |
| TJ | Tajikistan |
| TM | Turkmenistan |
| TR | Turkey |
| TT | Trinidad and Tobago |
| UA | Ukraine |
| UG | Uganda |
| US | United States of America |
| UZ | Uzbekistan |
| VN | Viet Nam |
| YU | Yugoslavia |
| ZW | Zimbabwe |

## AMENDED CLAIMS

[received by the International Bureau on 4 August 2000 (04.08.00); original claims 1-76 replaced by new claims 1-81 (8 pages)]

1. A batch method for treating a liquid comprising water, with a gas comprising ozone in a sealed vessel comprising the steps of:
    (a) manually introducing water to be treated into the vessel;
    (b) increasing the pressure in the vessel by supplying pressurized gas to the vessel to obtain treated water;
    (c) terminating the treatment cycle; and,
    (d) withdrawing treated water from the vessel.

2. The method as claimed in claim 1 further comprising the steps, after step (c), of further treating the water in the vessel until the liquid is treated to a desired level and signalling a user that the treatment is complete.

3. The method as claimed in claim 1 wherein the vessel has a water inlet and an associated releasable cap, step (a) comprises removing the releasable cap, pouring water to be treated into the vessel through the water inlet and attaching the releasable cap to the water inlet.

4. The method as claimed in claim 1 further comprising the step of, prior to step (b), generating ozone in an ozone generator.

5. The method as claimed in claim 4 additionally comprising the step of, prior to generating ozone, concentrating a source of oxygen to produce an oxygen enriched stream which is supplied to the ozone generator.

6. The method as claimed in claim 1 wherein the treatment cycle is terminated when the pressure in the vessel reaches a predetermined level.

7. The method as claimed in claim 3 further comprising the step of reducing the pressure in the vessel prior to withdrawing treated water from the vessel and the treated water is withdrawn from the vessel by removing the resealable cap from the water inlet.

8. The method as claimed in claim 1 further comprising the step, after step (c), of signalling a user that the treatment is complete.

9. The method as claimed in claim 1 further comprising the step of monitoring the treatment of the liquid and signalling the user that the liquid has not been fully treated.

10. A domestic method for treating a liquid comprising water in a sealed vessel, with a gas comprising ozone, comprising the steps of:
    (a) introducing the gas into the vessel;
    (b) increasing the pressure in the vessel;
    (c) reducing the pressure to promote the formation of microbubbles and obtaining treated water; and,
    (d) withdrawing treated water from the vessel.

11. The method as claimed in claim 10 further comprising the steps, after step (c), of signalling a user that the treatment is complete.

12. The method as claimed in claim 10 wherein the pressure is reduced at a rate sufficiently fast to produce microbubbles having a diameter from 1 to 20 microns.

13. The method as claimed in claim 10 wherein the pressure is reduced in under 2 seconds.

14. The method as claimed in claim 10 wherein the pressure is increased in step (b) to a pressure above 100 psig.

15. The method as claimed in claim 10 additionally comprising the step of concentrating a source of oxygen to provide concentrated oxygen which is supplied to an ozone generator.

16. The method as claimed in claim 10 further comprising the step of, after step (b), terminating the treatment cycle when the pressure in the vessel reaches a predetermined level.

17. The method as claimed in claim 10 further comprising the step of signalling the user that the liquid has not been fully treated.

18. A water purifier for treating a water with a gas comprising ozone to obtain potable water, the apparatus comprising:

(a) a vessel having a gas inlet port for introducing the gas into the vessel and the water inlet port having a manually openable cap for introducing water into the vessel;

(b) a pressurized source of the gas for treating the liquid in communication with the gas inlet port, the pressurizable source of gas supplying the gas at a pressure sufficient to promote the dissolution of ozone in the water; and,

(c) a disperser for introducing the gas into the liquid in the vessel.

19. The apparatus as claimed in claim 18 wherein the water inlet port also functions as the water outlet port whereby the treated water is withdrawn from the vessel by removing the manually openable cap from the water inlet.

20. The apparatus as claimed in claim 18 further comprising a valve for reducing pressure in the vessel after the gas in the vessel reaches a predetermined pressure.

21. The apparatus as claimed in claim 18 wherein the source of pressurized gas comprises an air pump upstream from an ozone generator.

22. The apparatus as claimed in claim 21 further comprising an oxygen concentrator for supplying an oxygen enriched stream to the ozone generator.

23. The apparatus as claimed in claim 18 wherein the vessel is removable from the water purifier.

24. The apparatus as claimed in claim 18 further comprising a signalling member to signal the user when the treatment reaches a predetermined level.

25. The apparatus as claimed in claim 18 further comprising a signalling member to signal the user when the treatment is successfully completed.

26. A domestic water purifier for treating water with a gas comprising ozone, the apparatus comprising:
(a) reactor means having at least one inlet port for introducing the gas and water into the reactor means;
(b) means for increasing the pressure in the reactor means; and,
(c) means for reducing the pressure to which the water is exposed in the reactor means to promote the formation of microbubbles.

27. The apparatus as claimed in claim 26 wherein the means for reducing the pressure comprises a valve for releasing pressure from the vessel after the termination of a treatment cycle.

28. The apparatus as claimed in claim 26 wherein the means for reducing the pressure reduces the pressure at a rate sufficiently fast to produce microbubbles having a diameter from 1 to 20 microns.

29. The apparatus as claimed in claim 26 wherein the means for reducing the pressure reduces the pressure reduces the pressure in under 2 seconds.

30. The apparatus as claimed in claim 26 wherein the means for increasing the pressure in the reactor means comprises an air pump upstream from an ozone generator.

31. The apparatus as claimed in claim 30 further comprising an oxygen concentrator for supplying an oxygen enriched stream to the ozone generator.

32. The apparatus as claimed in claim 26 wherein the reactor means is removable from the water purifier.

33. The apparatus as claimed in claim 26 further comprising a signalling means to signal the user when the treatment is successfully completed.

34. A domestic method of treating a liquid comprising water with a gas comprising ozone, the method comprising the steps of:
(a) providing the liquid in a treatment vessel;
(b) introducing the gas into the vessel to treat the liquid in the treatment vessel to obtain treated liquid;
(c) increasing the pressure in the treatment vessel; and

(d)using the increased pressure in the treatment vessel to control a dispensing cycle at a preset pressure level in the treatment vessel.

35. The method as claimed in claim 34 further comprising the step of venting at least a portion of the gas from the treatment vessel during step (b).

36. The method as claimed in claim 35 wherein the pressure in the treatment vessel is increased by reducing the amount of gas which is being vented from the treatment vessel.

37. The method as claimed in claim 34 further comprising the step of utilizing the increased pressure to pass the treated liquid through a filter located downstream from the treatment vessel.

38. The method as claimed in claim 34 further comprising the step of venting at least a portion of the gas from the treatment vessel during step (b) and passing at least a portion of the vented gas through the filter.

39. The method as claimed in claim 34 wherein step (d) comprises automatically dispensing the treated water when the pressure in the treatment vessel reaches a preset level.

40. A domestic method of treating water with a gas comprising ozone comprising the steps of:

(a) providing water in a treatment vessel;

(b) treating the water in the treatment vessel with ozone to obtain treated water and an off gas; and

(c) preventing the water from being dispensed from the treatment vessel if a predetermined level of treatment of water is not achieved based on the concentration of ozone in the off gas.

41. The method as claimed in claim 40 further comprising increasing the pressure in the treatment vessel and utilizing the increased pressure in the treatment vessel to dispense the treated liquid from the treatment vessel through a filter located downstream from the treatment vessel.

42. The method as claimed in claim 40 further comprising increasing the pressure in the treatment vessel and using the increased pressure in the treatment vessel to engage a dispensing cycle at a preset pressure level in the treatment vessel.

43. The method as claimed in claim 40 further comprising increasing the pressure in the treatment vessel and using the increased pressure to terminate a treatment cycle.

44. The method as claimed in claim 40 wherein step (c) comprises preventing the liquid from being dispensed from the treatment vessel if the concentration of ozone in the off gas is lower than a predetermined amount.

45. The method as claimed in claim 40 further comprising increasing the pressure in the treatment vessel and removing essentially all of the treated water from the treatment vessel prior to introducing another quantity of water into the treatment vessel wherein the increased pressure in the treatment vessel is used to remove the treated water from the treatment vessel through a filter located downstream from the pressure vessel if a predetermined level of treatment of the water is achieved whereby water fit for human consumption is obtained.

46. A domestic water purifier for treating water with a gas comprising ozone, the apparatus comprising:

(a) a housing having an upstream end and a downstream end;
(b) at least one inlet port for introducing at least one gas and the water to the housing;
(c) a plurality of spaced apart members rotatably mounted within the housing downstream from the inlet; and,
(d) a drive member for rotating the spaced apart members at a rate sufficient for dissolving at least a portion of the gas into the liquid to form a liquid/gas mixture and at a rate sufficient to maintain a laminar flow in a boundary layer adjacent the spaced apart members.

47. The mixing apparatus as claimed in claim 46 further comprising a pressure reduction zone downstream from the spaced apart members which is at a pressure sufficiently low to promote the formation of microbubbles.

48. The mixing apparatus as claimed in claim 47 wherein the gas/liquid mixture is subjected to an elevated pressure in the housing and the pressure to which the gas/liquid mixture is subjected is rapidly reduced as it enters the pressure reduction zone.

49. The mixing apparatus as claimed in claim 46 wherein the inlet port includes a member for dividing the gas into bubbles in the fluid.

50. The apparatus as claimed in claim 46 wherein the plurality of spaced apart members rotatably mounted within the housing are part of a prandtl layer turbine.

51. A mixing apparatus comprising:

(a) Prandtl layer means having a housing and disc means rotatably mounted within the housing;
(b) inlet means for introducing at least one gas and at least one liquid to the housing; and,
(c) means for rotating the disc means to create a boundary layer adjacent thereto, the inlet means positioned and the rotation occurring at a rate sufficient for dissolving at least a portion of the gas into the liquid to form a liquid/gas mixture.

52. The mixing apparatus as claimed in claim 51 further comprising means for rapidly depressurizing the gas/liquid mixture whereby bubbles having a diameter from 1 to 20

microns are produced.

53. The mixing apparatus as claimed in claim 51 wherein a catalyst reactive with at least one of the gas and the liquid is applied to at least a portion of one of the disc means.

54. The mixing apparatus as claimed in claim 52 wherein a catalyst reactive with at least one of the gas and the liquid is positioned in the means for rapidly depressurizing the gas/liquid mixture.

55. The mixing apparatus as claimed in claim 54 further comprising a passageway in flow communication with a source of ozone whereby the at least one gas comprises ozone and the at least one liquid comprises water and the mixing apparatus is used in the treatment of water.

56. The mixing apparatus as claimed in claim 51 further comprising a passageway in flow communication with a source of at least two gases are introduced into the housing and the at least one liquid is inert such that the at least one liquid is a media for the dissolution of one of the gases into another of the gases or for the reaction of the gases with each other.

57. The mixing apparatus as claimed in claim 51 further comprising a catalyst reactive with at least one of the at least one gas and the at least one liquid.

58. The mixing apparatus as claimed in claim 57 wherein the catalyst is a liquid or a solid form.

59. The mixing apparatus as claimed in claim 51 wherein the means for introducing at least one gas and at least one liquid to the housing comprises means for dividing the gas into bubbles in the fluid.

60. A method for treating water comprising introducing at least one oxidizing gas and water into a prandtl layer means and passing the gas and the water through the prandtl layer turbine to obtain a water/gas mixture.

61. The method as claimed in claim 60 further comprising passing the water/gas mixture through a pressure reduction zone to obtain a water/gas mixture at a reduced pressure.

62. The method as claimed in claim 60 further comprising exposing at least one of the water and the gas to a catalyst in the housing.

63. The method as claimed in claim 60 further comprising exposing at least one of the water and the gas to a catalyst in the pressure reduction zone.

64. The method as claimed in claim 60 further comprising introducing a catalyst into the mixing apparatus together with the gas and the water.

65. The method as claimed in claim 60 further comprising separately introducing the gas and the water into the housing.

66. The method as claimed in claim 60 further comprising mixing the gas and the water to create gas bubbles in the water prior to introducing the water and the gas into the prandtl layer turbine.

67. A method for mixing a liquid and a gas comprising the step of subjecting at least one gas and at least one liquid to an elevated pressure created at least in part by a plurality of rotating spaced apart members to obtain a liquid/gas mixture.

68. The method as claimed in claim 67 further comprising the step of treating the liquid/gas mixture to obtain a solution containing microbubbles.

69. The method as claimed in claim 67 further comprising the step of rapidly depressurizing the liquid/gas mixture.

70. The method as claimed in claim 67 further comprising the step of reacting at least one of the liquid and the gas with a catalyst.

71. The method as claimed in claim 68 further comprising the step of treating the solution with a catalyst.

72. The method as claimed in claim 68 wherein the at least one gas comprises ozone and the at least one liquid comprises water and the method comprises a process for the treatment of water.

73. The method as claimed in claim 67 wherein at least two gases are subjected to the elevated pressure conditions and the method comprises a process for the dissolution of one of the gases into another of the gases or for the reaction of the gases with each other.

74. The method as claimed in claim 70 further comprising the step of introducing the catalyst into the rotating spaced apart members.

75. The method as claimed in claim 70 further comprising the step of separately introducing one of the at least one gas and the liquid into the rotating spaced apart members.

76. The method as claimed in claim 67 further comprising the step of introducing a mixture of gas bubbles in the liquid to the rotating spaced apart members.

77. A mixing apparatus comprising:
(a) a Prandtl layer turbine having a housing and a plurality of spaced apart members rotatably mounted within the housing; and,
(b) at least one inlet port for introducing at least one gas and at least one liquid

to the housing at a flow rate sufficient for causing the spaced apart members to rotate whereby the rotation of the spaced apart members causes at least a portion of the gas to be dissolved into the liquid to form a liquid/gas mixture.

78. The mixing apparatus as claimed in claim 77 further comprising a pressure reduction zone downstream from the parallel spaced apart disc members which is at a pressure sufficiently low to promote the formation of microbubbles.

79. The mixing apparatus as claimed in claim 77 wherein a catalyst reactive with at least one of the gas and the liquid is applied to at least a portion of one of the parallel spaced apart disc members.

80. The mixing apparatus as claimed in claim 77 further comprising a catalyst reactive with at least one of the gas and the liquid is provided in the pressure reduction zone.

81. The mixing apparatus as claimed in claim 77 further comprising a passageway in flow communication with a source of ozone whereby the at least one gas comprises ozone and the at least one liquid comprises water and the mixing apparatus is used in the treatment of water.